

THURSDAY, OCTOBER 18, 1883

WILLIAM E. LOGAN

Life of Sir William E. Logan, LL.D., F.R.S., First Director of the Geological Survey of Canada. By B. J. Harrington, B.A., Ph.D. (London: Sampson Low and Co., 1883.)

CANADA claims the honour of being Logan's birth-place. During his lifetime she fully appreciated how much he had done for her, how unweariedly and generously he worked for her material interests, and that the renown he achieved cast a reflected glory upon herself. After his death it was but fitting that the story of his life should be written in Canada, where his best years were spent and where his main work was accomplished. And yet he was personally so familiar on this side of the Atlantic, so universally known and loved, so linked with early geological associations and with the fathers of geology in this country, that there may be readers of the volume before us who will be surprised to learn that he cannot strictly be claimed as one of the illustrious phalanx of geologists born within these islands. They may console themselves, if they choose, with the reflection that, though not actually ushered into life here, he came over in boyhood, received the closing part of his education at Edinburgh, began his geological career in Wales, and had already attained eminence as an original observer there before he was called upon to undertake the Geological Survey of his native province.

Logan was one of the most lovable of men. Simple and unsuspecting as a child, he was always at the service of any friend who needed his help, and too often also of strangers who preyed on his time and good nature. And yet with this gentle side of his character, there were combined a sturdy independence, an indomitable perseverance, an inexhaustible enthusiasm, which carried him up to and even beyond the limits of his physical strength. What infinite humour twinkled in those grey eyes, as he quietly told his reminiscences of camp-life, or of more civilised travel, or his experiences of politics and politicians with whom he had to fight for the existence of his Canadian Survey! How delicately and good-humouredly his satire played round these Philistines, who cost him withal many an anxious hour by day and many a sleepless hour by night! There was a calm self-possession in him, a consciousness of strength that could be put forth if needed though usually kept out of sight in the background, a determination to do his own duty and to see that others in the same matters did theirs.

Those who knew him and who recall these distinctive characteristics of him will be glad to have Dr. Harrington's memoir. The picture it gives of Logan's boyish years, told mainly in his own letters, is delightful. His overmastering affection for his family, his interest in everything at home, his eagerness to hear of and from each beloved one, his lengthy descriptions of all he thought likely to interest the home circle, are graphically told. It is not difficult to see how such a boy should have developed into such a man.

Born at Montreal in the year 1798 of Scottish parentage, Logan was sent at the age of sixteen to continue his edu-

cation at the High School of Edinburgh, where he so greatly distinguished himself that a brilliant career at the University was open to him. But he determined to enter upon commercial pursuits at once, and accordingly in the year 1817 took a place in the counting-house of his uncle, Mr. Hart Logan, in London. There he remained for fourteen years, during which there seems to have been nothing in his pursuits to develop the strong scientific bent that so completely dominated his later life, though we find that in his leisure he read books of science, especially in mathematics and chemistry, and asked to be supplied with some good work on mineralogy and geology. It seems almost by accident that he became a man of science. In the year 1831 he left London to take up his residence in Swansea, in charge of the books of a mining company in which his uncle was interested. But besides the books, he soon was called on to attend to the working of the mines and the smelting of the copper. Here at last he found an outlet for his love of nature and desire for scientific inquiry. He could not be content with the mere routine of his duties. Providing himself with the necessary surveying instruments, he began a geological survey of the Glamorganshire coal-field. He traced out the outcrops of the seams and positions of the faults with such minute care, that when some years afterwards De la Beche extended the Geological Survey to that region he found Logan's map so good that he gladly adopted it when it was generously handed over to him by its author. Logan's name accordingly appears on the published sheets of the Geological Survey of Wales, together with those of the members of the staff by whom the rest of the ground was examined. It was while looking after his uncle's coal-mines in this region that he was led to make his well-known observations on the rootlet-beds below coal-seams and to settle thereby the vexed question of the origin of coal.

There had been various efforts to establish a Geological Survey in Canada, but these had successively failed until 1841, when a sum of 1500*l.* was placed on the Parliamentary estimates. Next year the arrangements were completed, and the task of organising and conducting the Survey was intrusted to Logan. From 1842 till he resigned in 1869 he continued to be the life and soul of the Canadian Survey. The task he undertook was truly a colossal one. Almost nothing was known of the geology of the country. There were no maps on which geological lines could be traced. Thousands of square miles were unexplored trackless forest. Logan had not merely to find out the geological structure, he had to construct the very topographical maps on which it was to be delineated. He had to work with his own hands and train his assistants to work with him. He had to live among the wilds for months at a time, traversing hundreds of miles in canoes and on foot, with Indian guides and helpers. When winter made the further prosecution of field-work impossible, there were all the results of the summer to tabulate and to keep him fully occupied till it was time to start again. But his time was not always uninterruptedly given to these congenial labours. Though the Survey started under favourable auspices and with the support of the Government of the day, there were not wanting economists in and out of the Legislature who failed to see the usefulness of the enterprise and who objected to the

continuance of the annual grant for its prosecution. In nothing did Logan show his admirable tact and knowledge of men more than in the way he met these objectors, and turned them, if not into active friends, at least into passive though perhaps not wholly convinced spectators. Long before his death he had the satisfaction of seeing the establishment he had founded advanced in popular vour and equipped with a much more liberal endowment than he had been content with in its modest beginnings.

After the year 1851, when the reign of Universal Exhibitions began, Logan was frequently under the necessity of coming to Europe to look after the interests of Canada at the various capitals where the products of all nations were collected. There can be no doubt that though, so far as his proper scientific researches were concerned, these summers were entirely wasted, they were of the utmost service to the province. The collections of the Canadian Geological Survey were always one of the most interesting features in the Colonial galleries, and there can be no doubt that they did much to make the resources of the country widely known all over the world.

Of the value of Logan's services to science in general and to Canadian geology in particular, the best evidence and monument are to be seen in the voluminous series of Reports which he published, and in the truly admirable museum of Canadian minerals, rocks, and fossils which, with the aid of his colleagues, he formed at Montreal. As many of his letters show, he possessed no little literary faculty, but he never cultivated it, and indeed he hated the drudgery of writing. Had he been ambitious of fame, he might have attained a far wider reputation. His long years of exploration, his adventures and experiences by mountain, river, and forest, his felicitous power of rapid sketching, would have furnished him with ample materials for successive important and deeply interesting volumes, while his unflinching regard for truth and entire abhorrence of exaggeration would have lent to his pages a peculiar charm. But his ambition was to be at work in the field. There he continued at his post until after he had passed his seventieth year, when the confederation of the provinces extended the sphere of the operations of the Survey across the entire continent. Feeling himself no longer equal to the increased duties of his office, he resigned his connection with the Survey in the beginning of 1869, intending to devote himself more particularly to the investigation of some geological questions in which he took special interest, and to see more of his friends in Europe and of European geology than had previously been in his power. But he did not long enjoy the leisure he had so well earned. Retiring to Wales, where his sister lived, he spent there the autumn of 1874, but before the end of winter began to be seriously ill. He lingered until summer, and died on June 22, 1875.

The narrative of Logan's life by Dr. Harrington is simply and effectively given, much of its interest being derived from the extracts from the journals and letters. A few sketches are reproduced from the note-books. The only fault we are inclined to find with the book is that so few of these sketches have been given. We remember many a long year ago being allowed to peruse some of

the note-books, and laughing heartily over the humorous delineations of camp life on the Canadian rivers. Those who knew Logan will be glad to have this pleasant souvenir of him. Those who never knew him may learn from it something of the charm that will keep his memory green in the affections of many friends, both in the Old World and in the New.

ARCH. GEIKIE

OUR BOOK SHELF

The Sea Fisheries of Great Britain and Ireland. By E. W. Holdsworth. (London: Stanford, 1883.)

NOTWITHSTANDING the extensive literary productions connected with the Fisheries Exhibition itself, many works, suggested by it, have already appeared. One such is the volume before us—an admirable digest of the question in hand. In the present state of our knowledge, the chapter devoted to Ireland is exceedingly welcome, and it may not be too much to hope that, in spite of the gradual decline of its fishing industry, that country may yet seize hold of this, at least one remaining hope. The book is written in excellent style, clear and concise, well balanced, and up to date; of convenient size to be carried in the pocket, and provided with a good index, we can strongly recommend it to the host of visitors who frequent our coasts, and so often find their way instinctively to the nearest fishing village. One prominent feature is the description of the various "rigs," a subject of great importance of late, but which does not appear to have been sufficiently dealt with in the Fisheries manuals. The universal outcry of want of statistics is raised, and the writer has made the best of such as he has gathered—largely, from private sources. Those relating to the gradual increase of larger and improved boats in our fishing fleets are interesting, as leading up, we may hope, notwithstanding acknowledged difficulties in the way, to the introduction of steam-power. The illustrations are good, but additional ones, setting forth the different "rigs," and doing justice to other nets, as does that given to the beam-trawl, would be acceptable.

Agricultural Chemical Analysis. By Percy Frankland. (London: Macmillan and Co., 1883.)

DR. PERCY FRANKLAND has done excellent service by the publication of his book. There is good reason to believe that practical agriculturists are rapidly becoming alive to the importance of a knowledge of the scientific principles which underlie their art, and the action of the Science and Art Department in fostering the study of those principles is calculated to increase the intelligent appreciation of their value. The relations of chemistry to agriculture have been indicated in times past in this country in the writings and teaching of such men as Davy, Johnstone, Ure, and others, and in more recent times in the elaborate reports which we owe to the patient industry and zeal of Sir J. B. Lawes and Dr. Gilbert. Nevertheless it is to be feared that these works have been practically sealed books to the great majority of even the more enlightened of our agriculturists. Farmers are proverbially, and perhaps not unnaturally, a conservative class, and apparently nothing but the pressure of competition will force them from the beaten track. But science is abroad even in Arcady. Farmers who buy feeding-stuffs and artificial manures soon show a very rational appreciation of the significance and value of such items as "albuminoids," "soluble phosphates," and "available nitrogen." They will find all about such matters, together with much else relating to the chemistry of their art, in Dr. Percy Frankland's excellent little work.

T. E. T.

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LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

"Elevation and Subsidence"

I HAVE only to-day found time to read Mr. Starkie Gardner's essay on "Elevation and Subsidence"; in the last paragraph Mr. Gardner states that the views he advances are not accepted by all geologists. As one who is entirely opposed to them, will you allow me to state as briefly as possible on what grounds I object to the theory he propounds, and how I account for the observed facts he mentions in support of it.

It is generally admitted that nearly the whole of the sedimentary rocks were deposited in shallow water and in slowly subsiding areas; no one who has examined the Cambrian deposits of the Longmynd or the Silurian deposits of the Ingleborough district, will dispute this assertion. Mr. C. E. Dutton, in his recently published monograph of the survey of the Grand Cañon district states, "Throughout the entire Plateau Province the strata are shallow water deposits."

That in areas so widely separated the same phenomena should occur must necessarily suggest that similar processes of subsidence and deposition were taking place. The sea-bottom in these areas was, I believe, subsiding, not as Mr. Gardner suggests "*pari passu*" with the deposition and in consequence of it, but at a slower rate than that of the deposition, as the result of forces actuating the crust of the earth, which are quite independent of either deposition or denudation.

The result of a slow subsidence and a more rapid deposition would be that in course of time the surface of the deposited matter would rise above low-water level and would be subjected to the levelling or denuding action of the tides, any accumulation of deposited matter above this level would be swept into deeper water, all the phenomena of ripple marks, sun-cracked surfaces, and worm trails would occur, and any tendency of the slow rate of the subsidence to lower the surface receiving the deposited matter would necessarily be continually neutralised by fresh accumulations.

The areas of subsidence would probably present the appearance of the large stretches of sand-banks which may be seen at the mouths of the Mersey and of most of our rivers; the banks are exposed at low and covered at high water.

The accumulation of strata would continue as long as the subsidence took place (providing material were brought down to the sea); if the subsidence ceased, the material resulting from denudation would be spread over a larger area, but no additional thickness or strata could be formed above the level just mentioned; on the other hand, if the deposition ceased and the subsidence continued, an area of deep sea would be formed, and probably a stratum of limestone would be accumulated.

Further, the elevation of areas over which large accumulations of matter have been deposited cannot have taken place in consequence of denudation resulting in a greatly reduced weight being distributed over the area of elevation, as suggested by Mr. Gardner, for denudation has necessarily followed elevation.

Every formation appears to me to contain evidence that subsidence took place independently of deposition, and elevation independently of denudation.

The Cambrian and Silurian rocks in this country appear to have been deposited over areas in which the rate of subsidence has at one time been less, at another time greater, than the rate of deposition; the Silurian limestones no doubt represent periods of subsidence during which no deposition of denuded matter took place. At the close of the Silurian era an upheaval must have occurred, the result of forces powerful enough to overcome the weight of both the Cambrian and Silurian formations, which appear to have been thrown into a series of vast anticlinal and synclinal curves. In the Longmynd district and near Ingleton the strata are either vertical or inclined at a great angle.

One result of this upheaval would be the formation of comparatively shallow lakes or inland seas, in which the Old Red Sandstone would be deposited; another would be the formation of a land surface of Silurian rocks which would be subjected to subaerial denudation.

According to Mr. Gardner's theory (in support of which he refers to the Himalayan range), the elevation of the Silurian rocks should have been continuous, for denudation would affect them in the same manner as it is said to affect that great range, and possibly the accumulating Old Red Sandstone would react on the Silurian land surface as Mr. Gardner suggests the subaerial deposits of the sub-Himalayan range react on the main mountain chain.

Instead, however, of the continued upheaval which theoretically should have taken place, a subsidence of the denuded Silurian rocks commenced apparently over a very large portion of this country, resulting in the formation of a deep sea in which the limestone, the base of the Carboniferous series, was deposited, in Derbyshire to a depth of nearly 5000 feet. Did this vast accumulation of limestone cause a further subsidence? No, the forces actuating the crust of the earth were in no respect interfered with; a period of elevation must have followed, and a comparatively shallow sea was filled up with the Yoredale shales and millstone grits, and a land surface formed represented by the lowest coal seam—a coal seam that may be measured by inches, nevertheless it was followed by a subsidence.

Surely the force producing this subsidence was as independent of the coal seam as that producing the previous upheaval was independent of the limestone.

Throughout the whole series of the coal measures comparatively thin accumulations of coal, representing periods of rest or perhaps slow elevation, were followed by prolonged periods of subsidence.

I do not think the depressed areas bounded by vertical cliffs seen by Mr. Gardner in Iceland at all help his theory; they are just the phenomena one would expect to find in a highly volcanic district; on a very small scale they may be seen in any district from under which material has been removed.

T. SINGTON

Grove Terrace, Kersal Moor, Manchester, September 22

I FEAR readers of NATURE must be weary and the courtesy of the Editor taxed by the demands on its space. Moreover but little actually new information has been elicited, though thanks are due to the Rev. Osmond Fisher and Dr. Ricketts especially for their contributions.

That depression of the earth's crust follows on the addition of weight and elevation ensues on its removal are facts that can no longer be disputed or explained away. Those gentlemen, however, who object that the cause and effect do not follow each other foot by foot are a little unreasonable, for resistance more or less stubborn must be encountered, which may check the process for a space, and then by yielding at last considerably accelerate it. Those again who will see nothing in the array of facts beyond fortuitous connection must be allowed to hold their opinion.

The matter rests thus:—The observations of many authors have induced a belief that sedimentation causes subsidence, through the increase of weight acting on and displacing a viscid layer underlying the solid crust. If this is so, the displaced matter must find room elsewhere, and it is only reasonable to suppose that a slight elevation or bulging of the crust must result in more or less adjoining areas, and chiefly under areas in which denudation had already weakened the resisting power by reducing the pressure. Applying the idea to coasts, where we have for the most part parallel lines of denudation by wave action and sedimentation through the deposition of material dislodged by the waves, I have endeavoured to show that their chief physical features accord with the "elevation and subsidence" theory, though more observations are greatly to be desired. But, even including coast lines, the examples are so far but local manifestations, yet, if true in less matters, why not in greater? Oceanic basins, if permanent throughout geological ages, as they probably have been, must have been areas of sedimentation on a stupendous scale, and the pressure they exert (increased as subsidence deepens the column of water) must give rise to corresponding displacements on a gigantic scale, and which would seek relief along the nearest existing lines of weakness. These lines would either be in the ocean and result in banks or ridges, or else be along their margins and result in mountain chains, and sometimes breaking through in volcanic outbursts. The larger would overcome the smaller, and a delta or coast line subsiding through its own sedimentation might occur along the line of upheaval and be forced upward, or a vast displacement or eruption might relieve the tension to an extent that would take ages of accumulation to reproduce. This

theory seems to me to be natural, and to accord with facts all round, but still it may be wrong. Those, however, who would assign all elevation and subsidence to secular cooling and tangential thrusts through shrinkage are revelling in their own imaginations, for there is no reason why the earth's nucleus should not have cooled as evenly as a cannon ball or piece of pottery, or other homogeneous body; and the records of the Palæozoic rocks, when we may suppose shrinkage would be more active, certainly show that its surface was then relatively level, and without deep seas or great elevations on land.

J. STARKIE GARDNER

P.S.—A good example of subsidence may be seen in the Tilbury Dock works in progress. So far as I could see, Thames mud is being cut through to a depth of some ninety feet, the upper part at least being filled with debris of reeds interstratified with peaty matter or decayed reeds massed together. The whole must have been deposited at or near high-water level, and so recently that at thirty feet depth the decayed vegetable matter still smells offensive.

The Apparent Disappearance of Jupiter's Satellites on October 14

RAIN fell without intermission on the afternoon and evening of October 14, but at 11h. it ceased and the clouds broke. Later in the night the sky cleared, but there were showers at short intervals.

At 15h. 15m. I observed Jupiter with a 10-inch reflector, power about 212, and saw that the third satellite was the only one visible. It was situated close to the east limb, and its disk appeared somewhat faint, as if much clouded over with spots.

15h. 55m.—The third satellite is entering upon the planet's disk at a point in the same latitude as the upper side of the great south equatorial belt. The fourth satellite is also seen coming off the west limb. It looks remarkably faint. At this time the configuration of the planet was extremely interesting with the two satellites hanging upon the limbs.

16h. 0m.—The fourth satellite appears to have completed its egress, and is evidently much in advance of the time given in the *Nautical Almanac*.

16h. 15m.—The first has now reappeared from occultation at a point in the same latitude as the north equatorial belt. This belt is a far more prominent feature than during the last opposition.

16h. 19m.—A large white patch on the planet's equator is crossing the central meridian. On its north side the equatorial belt is very dark.

16h. 30m.—The third satellite is visible as a very dark spot projected upon the south equatorial belt, which is the darkest belt upon the planet.

17h. 0m.—The second satellite is seen as a bright spot on the interior margin of the west limb, and will shortly begin its egress. It has crossed Jupiter in a latitude corresponding with the equatorial edge of the great south belt. The third satellite is now perceptible as a black spot pursuing its course along the south belt. The chief condensation of shading apparently lies on the south side of the satellite, but the telescopic image is not satisfactory.

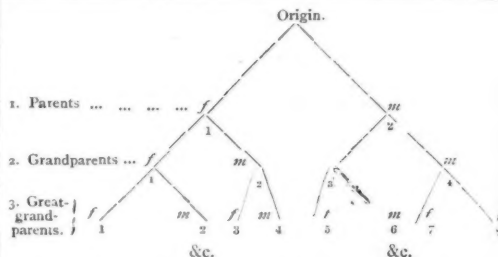
The disappearance of the satellites on this occasion can hardly be said to have been complete, for at no time were they all included within the margin of Jupiter. While the third entered upon the disk the fourth released itself, and the two formed a curious configuration hanging upon the limbs. The third and fourth satellites were extremely faint when clear of the disk, and their surfaces are evidently very feebly reflective compared with that of their primary. It is significant that the third, though projected upon the darkest belt of Jupiter, was visible as a black spot. The fourth probably crossed the planet as a black spot also, though I made no attempt to distinguish it under this aspect, owing to frequent interruptions by clouds and rain.

Bristol, October 15

W. F. DENNING

Arithmetical Notation of Kinship

It seems to me that the elegant arithmetical notation for ancestors proposed by Mr. Galton in his recent letter to *NATURE* (September 6, p. 435) may be further simplified. The modification consists in first counting the grades and then counting the species of the grades, as shown in the following diagram:—



Thus mother of mother of father is of the 3rd grade and of the 4th species, and may be denoted by 3, 4. Let q denote any grade and r any species, then q, r is a complete specification for an ancestor. The rule for analysing such a specification is—Divide r by 2, adding a unit when the dividend is odd, and repeat the operation ($q-1$) times; then when r or a quotient is odd, substitute *father*, and when even *mother*.

Take, for example, 3, 5. We get 5, 3, 2, hence father of father of mother. Take 5, 5, we get 5, 3, 2, 1, 1, hence $ffmf$.

If we compare together the ancestors of the same species number, we shall find that they have all the figures the same until we come to unity, and that the generic difference depends on the number of unities. The truth of this may also be seen by considering the mode of construction of the diagram.

Mr. Galton's 253 is, in this notation, 7, 126. Analysing we get—

126 63 32 16 8 4 2

The ancestor 7, 1 of my notation is 128 in his. The analysis of the latter is—

128, 64, 32, 16, 8, 4, 2,

while that of the former is evident by inspection, namely—

1, 1, 1, 1, 1, 1, 1.

With the double notation we know that when we come to unity, each of the following symbols must be f ; and that when we come to a power of 2, each of the following symbols must be m , followed it may be by some f 's.

ALEXANDER MACFARLANE

4, Gladstone Terrace, Edinburgh

A Green Sun

IN connection with the phenomenon recorded in your last number (p. 575), the following extract from my journal (Sunday, July 14, 1878), when just north of the Arctic Circle on board the *Fenja Lie*, may be of some interest:—

"To-night the sun sets in a sky as pure and cloudless as that of yesterday; but the colours are quite different. Now there is no crimson, but in its place orange, yellow, and molten gold. All this exquisite beauty of colour is limited to a particular part of the sky, and that not the west, but the north. Yes, strange as it may seem, the sun sets scarcely a single point from the north, and rises again nearly in the same place, barely two points apart. Some heights are lighted up with the glow, but for most of the time all around, save in the bright, favoured north, is cloudless darkness and gloom; which yet is not the darkness of night, but a grim, stormy, vague gloom in broad daylight. The afterglow that follows sunset dies out, and without any sensible interval of time, revives nearly in the same place; the colour brightens, and some small streaks of clouds grow brighter and brighter, until the sun—the GREEN sun—appears. A distant low range of rocks comes between us and its point of rising, and, as we glide on, an opening between them shows us the sun, a bright emerald, as pure and brilliant as ever gem that glistened; again we lose it, and again an opening shows it to us in its own golden light; and then once more it is the bright green; and now it rises higher, clears the ridge, and is once more the golden orb. This is what we saw, but another observer assures us that when first he saw it, the colour was a fiery red, which soon turned to green. Probably an optical effect of what is called polarisation of light, as these complementary colours seem to show." (A Long Day in Norway, published in *The Month* in 1878-9.)

HENRY BEDFORD

All Hallows College, Dublin, October 13

"Zoology at the Fisheries Exhibition"

IN your issue of the 20th ult. (p. 489) a direct challenge is made upon several points as to the veracity of my former letter. "The Writer of the Article" states what he terms certain "facts"—the first being that I informed the jury of Class V. that certain corals under my name, 813 *b*, were in the case with Lady Brassey's corals, and formed part of that collection. I beg entirely to deny this. What I stated to one of the members of the jury in answer to his allusion to my exhibit was, that owing to my being so busy I was unable to exhibit my own corals, and that all my energies had been thrown into the arrangement of Lady Brassey's case. Whoever informed "The Writer of the Article" must have greatly misunderstood my statement. The second "fact" with regard to the opinion of experts I think I need not answer. Opinions may differ. With regard to "fact" three, that neither the series of corals in the British Museum nor those of the Challenger Expedition have been accessible for purposes of examination for some considerable time. It will be sufficient to say that my description and figures of Lady Brassey's corals were published in the *Annals and Magazine of Natural History*, vol. ix. No. 50, in February, 1882, some time after the publication of the volume of the Challenger Reports containing Mr. Moseley's monograph of the "Hydrocorallinidæ," and a considerable time after the specimens themselves were exhibited to public view in the galleries of the British Museum. Those specimens, together with the other corals of the general collection of the British Museum have only been withdrawn from public view within the last few months.

BRYCE-WRIGHT

Organic Evolution and the Fundamental Assumptions of Natural Philosophy

BY the principle of heredity we understand a tendency in an organism to reproduce in successive order the variations which appeared in its ancestors, the leaning being on the whole to fixity of direction: by the principle of variation the tendency of an offspring to vary in a degree more or less from its parents. Included in heredity, I suppose, are the tendencies to vary, as well as the actual succession of changes in the life-history of the ancestors of the organism: those tendencies to vary being conceived of as series of which some terms may modify or counteract others. If I am right in this description, it appears to me that heredity is an example of inertia acted on by a principle analogous to the first law of motion, and very closely allied with it, if indeed it is not the case that the laws of motion are special cases of wider principles or laws. Following the same line of thought, "variation" may be explained as action analogous to that of forces on a body drawing it from its straight line of motion or its rest. The forces (if I may use that term) which thus cause variations in any particular organism would be:—

- (1) The resultant of difference of conditions cooperating with
- (2) The resultant of inherited tendencies.

Again, answering to the second law of motion, we may perhaps assume that degree of variation is proportional to the forces acting, namely, proportional to the intensities of (1) and (2) above and to the correspondence or divergence of direction in which they tend. If the above hypotheses are accurate, we have, I think, an explanation of the possibility of protozoa, &c., remaining practically unchanged during great changes of conditions. For those genera which show a tendency to great variation in the individuals at the same time seem to present no fixed line of tendency. The result of heredity (as defined above) in these cases is not definite variation tending in certain fixed directions, but great individual or indefinite variability. And their phenomena of reproduction I think account in some degree for this.

On the same hypothesis we may explain, amongst other things, the plasticity of organisation of cultivated plants. One of the conclusions also that would follow would be that "reversion" would not happen except as a re-ultant of the tendencies in fixed directions having nullified each other, or having converged in the direction of reversion.

To carry the analogy further. Answering to the third law of motion, that action and reaction are equal and opposite, we may perhaps assume that alteration of some organs or properties in the organism, wrought by change of conditions together with heredity, brings about that modification of other properties or organs which Darwin spoke of under the name of "correlation."

I should feel indebted to any one who would point out any

mistake that I have made in this, or would show if the assumptions I have made are untenable.

FREDERICK W. RAGG

Masworth Vicarage, Tring, September 25

Curious Habit of a Brazilian Moth

MR. E. DUKINFELD JONES (*NATURE*, May 17, p. 55) may be interested to learn that the habit of *Panthera apardalaria*, which he describes, of sucking up water and discharging it simultaneously *ab ano*, is not confined to the moth noted by him, but is common to several other lepidopterous insects.

I have watched several species of *Callidryas* and *Pieris* both in Ceylon and Brazil, doing the same thing; also *Papilio Erithonius*, Cram, in the latter place, and its ally, *P. Demoleus*, L., at the Cape of Good Hope. I have seen the "white butterflies" in thousands, settling on the mud and damp places in the jungle paths, in all these countries, with their trunks thrust into the soil, drawing up copious supplies of water as if they were so many miniature Abyssinian pumps! The drops ejected were by no means "minute," were rather very large, and I should say 60 would much overtop the marks in a minim measure glass, or, roughly speaking, more than fill an ordinary teaspoon, said to equal sixty drops. I have somewhere (I forget where), among my fugitive writings, noted this fact: stay, I noted it once at least in the *Field* in 1873, February 7. A large moth (*Catocala*?), a fine "yellow underwing," visits the toddy vessels in Ceylon, and gets very drunk, not having joined the "blue ribbon" army, nor having the fear of Sir Wilfrid Lawson before his eyes! I suspect this fellow finds the liquor too good to eject so rapidly, but I have seen small moths of various kinds drinking ordinary sap, and ejecting it like the before-named butterflies.

British Consulate, Noumea, July 24

E. L. LAYARD

Meteors

DURING the month of August I watched the meteors from Logiealmond parish manse, Perthshire, but there the weather was most unpropitious for observing any celestial phenomena, so only a few were seen; whereas there in August last year I witnessed some gorgeous showers of brilliant meteors, which the readers of *NATURE* may recollect. Here in Paisley, on the last Sunday of August, about 11.50, a very large meteor blazed from due south to due east, with a long train, lasting for a minute, and keeping parallel to the horizon, nearly midway to the zenith. The month of September was unusually rich in meteors, but they were generally small and transient, and seemed to be very remote, some of them dashing straight up. A bright but momentary one shot up at right angles from the Pleiades. On September 24, at 10.55 p.m., a very peculiar meteor started from Aldebaran, and exploded in the head of Pisces, under the Square of Pegasus. It was dimly seen through a haze, with a long streak behind, giving unmistakable evidence of its large size; yet, though scarcely seen above its path, brightly shone the Pleiades, Aries, and the Square of Pegasus. On the 25th, at 11.56, a similar one, scarcely seen, sailed through a haze from Pisces to Altair, exhibiting a long trail of broad light, showing that it was a large one. September 30, at 0.12, a meteor considerably larger and brighter than Jupiter passed from the third bright star in Auriga (taking Capella as the first), and exploded close to the lower Pointer in the Plough, leaving a long train of reddish light behind it. On the night of the 29th and morning of the 30th, up to 4, the meteors were unusually large and of longer duration, and altogether more numerous than I have ever seen them in September. A few momentary meteors were seen on the night of September 30 and morning of October 1.

Mossvale, Paisley, October 1

DONALD CAMERON

The Uselessness of Vivisection

You will probably permit me to point out that it would be only reasonable for Mr. George J. Romanes to possess a little information on the subject he is dealing with before he accuses another of being "in a quagmire of ignorance and inaccuracy." The pamphlet against which he levels his abuse does not deal with physiology, but with surgical questions. My efforts have not been directed so much against vivisection as against the mendacious statements which have been made concerning advances in surgery alleged to be due to its practice. These have been used to hoodwink the legislature and blindfold

the public, and they deserve the utmost condemnation. If physiologists can make out a case for themselves, I for one am prepared to give it the utmost attention, but they must not bring to their aid false illustrations from a branch of science with which I think I may be permitted to say I have had a large experience.

Birmingham, October 6

LAWSON TAIT

It seems sufficient for me to observe, in reply to the above, that before writing my review of "Physiological Cruelty" I took the trouble to acquaint myself thoroughly with the latest edition of Mr. Tait's pamphlet.

GEORGE J. ROMANES

Breeding of "Hapale jacchus" in Captivity

MR. MOSELEY'S Marmosets (*NATURE*, vol. xxviii. p. 572) are by no means the first instance in Europe, or even in England. Edwards, more than a hundred years ago, recorded a case in Portugal; and Frederic Cuvier had three born in Paris in 1819 (*vide* Sir William Jardine's *Natural Library—Mammalia*, vol. i.). A relative of mine brought a pair of this species from Pernambuco in 1863, and kept them in his kitchen at Surbiton. In April, 1865, I was shown two living young ones which had been born a few days before. In the *Proc. Zool. Soc.* for 1835, births of marmosets of an allied species (*H. penicillatus*) have been chronicled as occurring in this country.

W. C. ATKINSON

Streatham, S.W., October 13

TELESCOPIC WORK FOR THE AUTUMN

WITH Mars, Jupiter, and Saturn so favourably visible in the sky during the ensuing autumn and winter months, we think it may be interesting to call attention to some of their more prominent features, and to ask amateurs and others who devote themselves to the attractive field of planetary observation to make a combined effort, not only to substantiate such facts as are already known with regard to the physical appearances of these bodies, but to endeavour to glean something new concerning them. For, notwithstanding the diligence with which these planets have been scrutinised in past years and the many curious facts that have been brought to light, it must still be confessed that there remains much to be done. Our knowledge is admitted to be extremely incomplete. The powerful instruments of the present day do not seem capable of rendering us efficient aid in this respect; indeed we shall find by a comparison of results that we owe most of our discoveries to telescopes of moderate aperture. The real explanation probably is that, with increase of aperture, definition, especially of the brighter planets, becomes less perfect. Faint markings are obliterated or seen unsteadily and uncertainly in large instruments owing to glare, the difficulty of getting a sharp, hard disk with so much light, and the constant undulations of the atmosphere. With moderately small instruments the conditions are in many respects more favourable. The image is sharply defined, and though the quantity of light may be somewhat deficient, there is an absence of glare and of that atmospheric interference which are inseparable from large apertures. Moreover, the eye is more capable of prolonged observation and is enabled to glimpse the faintest details on an image of moderate intensity. The deficiency of light in small instruments is therefore to some extent a recommendation when it is accompanied with extreme sharpness of definition and when the amount collected by the object-glass or speculum is sufficient to allow a power to be used which displays a fairly large disk without destroying the quality of the definition. Indeed one great desiderative in such cases is to utilise light and power in agreeable proportion, for this is a very essential requirement, which is, however, often neglected, and is frequently the source of disappointing experiences. Amateurs who are careful to consider these matters will be enabled, though their instruments may be of comparatively small reach, to do

much useful work in many departments of observation, and particularly in that relating to planetary markings.

With regard to Mars, high powers are very requisite because of the small diameter of the planet. Hence a fairly large aperture is necessary, for, unless the disk is considerably expanded, it is impossible to trace the chief features satisfactorily. In the case of Jupiter the use of high magnifying powers does not apply with so much force, the apparent diameter of the disk being greater. But this planet is a somewhat difficult object to define satisfactorily. The best telescopes will often fail to show the contour of the disk with desirable sharpness. Hence it is that this object with large apertures is troublesome and to some extent disappointing. This is certainly the case when we consider how efficiently and successfully small instruments perform upon this planet, and with what readiness the faintest and more minute of the details are distinguished. As to Saturn, the conditions are somewhat different. Here there is less light and the telescopic definition is better, so that large glasses possess an undoubted advantage.

The ensuing opposition of Mars is not a favourable one, but many of the most interesting and now well-known features of the planet may be observed in good instruments. The curious network of "canals," as discovered by Schiaparelli, and their duplication, as seen by the same observer during the last opposition, in the winter of 1881-82, should be looked for, as some doubts have been expressed as to the reality of these phenomena. The question is naturally asked, How is it that they are now seen with so much distinctness again and again with a refractor of only eight inches aperture, when large instruments have utterly failed to reveal them? Schiaparelli, it is true, works in a climate highly favourable to such delicate work, and his telescope, though comparatively small, is yet of the finest possible quality. But even with the prevailing conditions so eminently conducive to the attainment of such important results, it must still remain matter for surprise that, as the celebrated Italian astronomer himself put it, "the greater number of canals and of their pairs were observed with comparative ease whenever the air was still, and only a few cases required a special effort on the part of the observer."

These so-called canals appear from Schiaparelli's charts to be very narrow dark markings, running generally in straight lines, and often intersecting each other so as to constitute a perfect network about the equator and in the region south of it. Many of these lines were seen to be double in January and February, 1882, and the inference is that, as these duplications had escaped observation during the more favourable opposition of 1879, they are subject to periodical variations, or in any case represent phenomena of temporary character. They undoubtedly exhibit a most extraordinary arrangement, and such as naturally to call forth some amount of objectional comment from those who, though familiar with the telescopic aspect of the planet, have never seen it as Schiaparelli depicts it. In fact his delineations give a boldness and definiteness of outline in the smallest details which no other observer is able to corroborate. The extreme delicacy of shading and softness of outline so characteristic of many of the features of this planet as displayed in our best telescopes seem wholly wanting, and we have presented to us an elaborate complication of hard, dark lines which bear little analogy to our own impressions.

It has been suggested that many of these so-called "canals" are the edges of half-tone districts on the planet, and possibly this may be so in certain cases. But we must not forget that the eminent author of these important discoveries expresses himself very confidently as to their existence, for he has seen them repeatedly, and at times when the conditions were not favourable to the detection of such difficult markings. Probably something

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of them may be again observed during the ensuing winter, although the apparent diameter of the planet is very small and opposed to a critical investigation. Schiaparelli has, however, pointed out that "on January 1, 1884, the position of Mars with respect to its solstice will be identical with that which it had on February 13, 1882, and its apparent diameter will be $13''$, that is to say, about equal to the apparent diameters which the planet had during the discovery of the parallel canals. Every telescope able to distinguish a dark line $0''.2$ in breadth on a bright ground, and to separate the one from the other two such lines when the interval between axis and axis is $0''.5$, could be employed for these observations and to study the duplications if these should be reproduced."

It is to be hoped that some of our best instruments will be devoted to this work during the ensuing winter, and that something of these curious features will be observed before the favourable opposition of 1892, when they will certainly be seen if ever. But there is the alternative that they are possibly variable and subject to periodical disappearances, though we can hardly consider this probable in view of the permanent character of the chief markings on the planet.

Jupiter has always been an object of great attention to the possessors of telescopes, not only on account of the readiness with which the satellites may be perceived, but also on account of the prominence and variety of his belt scenery and the marked changes which it undergoes from year to year. The well known red spot which appeared in the planet's southern hemisphere, and which first came prominently into notice in July, 1878, has proved a great stimulus to observation of late years. The large dimension of this spot, its intensely red colour, its definiteness of outline, and its durability have combined to render it an object of extreme interest, and the phenomena of this planet, whenever it is described in future years, will never be complete without a reference to this marvellous feature. Persistently visible throughout a period exceeding five years, during which it has completed more than 4500 rotations, it would be imagined that it must afford an excellent means of fixing the rotation period of Jupiter with a degree of exactness far surpassing all previous efforts. But the spot has shown a retarded motion which constantly causes it to lag behind its predicted place. In other words, the rotation period has been lengthening. Mr. Marth found the average time to be 9h. 55m. 34.47s. from the observations between 1878-1881, but the spot now crosses the central meridian of Jupiter about two hours after its predicted times based on the period just referred to. In fact its time of rotation has lengthened fully three seconds during the past two years. But even had this spot been influenced by a perfectly accordant motion during the whole period that it has been watched, we could not regard its time as showing the true length of the Jovian day, for the disk of this planet exhibits a variety of spots which generally move much swifter than the red spot. On the equator the markings rotate in 9h. 50m. 7s. Both the dark and bright spots which alternate with each other on and near the equator, and are included in the two principal dark belts, participate in this rapid movement, and they show a fairly regular period, so that it is impossible to decide at present as to the true rotation of the planet's sphere. The brightest spot of all has been attentively followed since November, 1880, and it is found that relatively to the red spot it has, owing to its greater velocity, completed twenty-three revolutions of Jupiter. In other words, during 1026 days its swift proper motion has enabled it to sweep round, no less than twenty-three times, the vast circumference of the Jovian sphere! What phenomena can possibly have given rise to such a remarkable difference of motion in objects of fairly permanent character? The explanation is involved in mystery, and may never be forthcoming, but there can be no question as to the importance of

following up these observations. The red spot now seems unfortunately to be in a state bordering on extinction. It has become so faint that it is only distinguished with care under circumstances of favourable definition.

Apart from the spots, which evidently offer a large field of very interesting work, there are the belts, which are constantly varying in colour, position, number, and intensity. At every opposition of the planet a series of sketches should be made of the aspect of the disk, for some important issue may result from the comparison of such drawings if existing over a long number of years. Some of the leading features may be found to recur at certain definite periods, for the drawings of the present day show many curious forms bearing a striking analogy to some observed at former times. In any case a reliable set of sketches for each opposition must give us an excellent basis for investigating the varying features of this planet, and may afford us a clue to some of the marvellous changes evidently progressing upon his surface. Telescopes of very moderate size can be usefully employed in these observations. I have seen sketches of Jupiter made with a 36-inch reflector, 18 $\frac{1}{2}$ -inch refractor, 18 $\frac{1}{2}$ -inch reflector, and with many other instruments ranging from 12 to 18 inches. I have also examined a large number of similar sketches obtained with refractors of from 4 $\frac{1}{2}$ inches to 6 inches, and reflectors from 5 $\frac{1}{2}$ inches to 6 $\frac{1}{2}$ inches, and carefully compared them together. The large instruments appear to have had no advantage whatever. Indeed, judging from the amount of detail presented in the sketches, and from the descriptions accompanying them, the small apertures would seem to have rather the best of the comparison!

One explanation may be that the detail rendered visible on Jupiter by large instruments is so extensive that it cannot adequately be delineated during the short interval available for sketching. The features change very rapidly, owing to the planet's swift axial rotation, and drawings made on different nights, when the longitudes are assumed to be coincident, are not reliable, because the different markings have become severally displaced owing to their differences of motion.

Saturn, though diversified with belts similarly to Jupiter, is less attractive as an object for telescopic study. The image of Saturn is beautiful as a picture, but there is a sameness about it which observation, renewed again and again, has a tendency to make monotonous. His belts are generally faint, and seldom show spots of decided character. During the last opposition the planet's southern equatorial belt was very dark and well defined, and exhibited differences in depth of shading, but these were not sufficiently distinct to be followed. On the equatorial margin of this belt the disk was very bright, and immediately contiguous to it are signs of white spots, which would suggest very similar phenomena to that discerned on Jupiter. Spots of sufficiently definite outline to be observed with certainty upon the globe of Saturn are extremely rare. Prof. Hall's white spot of 1877 affords one notable example of this kind, and doubtless the number of such observations would be greatly increased were more attention directed to this planet. Though sketches of Jupiter are frequent enough, we rarely see attempts to delineate Saturn, and thus we have comparatively few records as to the arrangement of his belts. This is to be regretted on many grounds. No doubt the rings of this planet monopolise observers to such a degree that they neglect other phenomena which, though less attractive, may be of greater significance and interest. Whenever such observations are practicable, particular attention should be given to the configuration of the belts, and a searching examination made for any definite markings which may be sufficiently obvious and permanent to be followed on successive nights, and thus enable a new determination of the rotation period. William Herschel found this to be 10h. 16m. 0.44s.,

and this has received excellent confirmation from Prof. Hall's observations in 1877, which indicated a period of 10h. 14m. 28.8s. Schroeter also glimpsed several spots indicating periods of about twelve hours, but these observations are probably erroneous, as they differ so widely from the corroborative results of Herschel and Hall. But it is possible that these distinctive markings on Saturn give anomalous periods similarly to the spots on Jupiter, though hardly to the extent of the differences between the existing observations. Were this planet more sedulously observed, it is certain that we should obtain some new and interesting facts with reference to his globe and rings. As to the belts, they are occasionally very plain; Grover has seen them with only 2 inches of aperture, and the writer distinguished them well in 1881 with a $\frac{2}{3}$ -inch O.G. What, therefore, can be so readily seen in small telescopes ought to come out with considerable detail in the large instruments of the present day. As to the system of rings, it forms a complicated object for study. The marked differences in their tints and brightness should be recorded on all occasions. Cassini's division is always plain, but the outer and more minute division of Encke has sometimes defied the power of our best telescopes. It apparently varies both in position and intensity. Other faint subdivisions are sometimes traced, but they are very difficult objects, and seldom seen with certainty. The crape or gauze ring, together with other details, such as the anomalous shadow of the ball upon the rings, supply an endless store of curious appearances requiring further elucidation.

There is no doubt that, notwithstanding the mass of interesting facts gleaned in past years respecting the physical aspects of Mars, Jupiter, and Saturn, there remain many novel features to be distinguished, and many new facts to be described. Observers, therefore, who make these observations a specialty should endeavour not only to confirm former results, but to make some advance upon our existing knowledge.

We have not space in the present paper to refer to the satellites of these several planets, but may possibly be able to do so on a future occasion. W. F. DENNING

THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES¹

II.

HAVING now given a description of the instruments used in the section of linear standards, we come to the apparatus belonging to the section of standards of weight.

As regards the essential instrument connected with the process of weighing, the International Bureau possesses one of the most remarkable collections of balances of precision existing in the world. Of these the principal ones have been constructed by the house of Rüprecht of Vienna. The large engraving accompanying this (Fig. 3) represents in its entirety the spacious chamber in which they are set up. In addition we gave a special sketch (p. 465, Fig. 2) of the balances principally designed for comparison of standard kilogrammes. This balance is constructed in such a manner as to adapt it for being worked at a distance, whereby it is kept free from the disturbing influence always occasioned in the process of weighing by the proximity of the observer, in consequence of the variations of temperature which his presence close to the balance gives rise to. In the case of the instrument now in question, the observer, having prepared his weighing apparatus the preceding day,—that is, placed the weights he will have occasion to use in their right positions in the pans of the balance,—avoids any longer going near the balance. Standing in front of his telescope he performs all the operations involved in weighing that is, he puts the weights on the pans, releases the pans, and then the

beam, and measures the oscillations of the beam; then changes the weights from one side to the other, placing that to the right which was at the left, and conversely, &c., the whole at a distance of four metres. For that purpose the balance is provided with a mechanism very ingenious and of perfect precision which works automatically by means of handles fixed to the extremity of long rods. The oscillations of the beam are read by the reflection of a graduated scale on a mirror borne by the beam; it is the image of that scale the observer sees displacing itself slowly in his telescope while the balance oscillates. He notes a certain number of successive oscillations, and thence calculates the position of equilibrium.

Three other balances, of the same model but smaller, are intended for comparisons and adjustments of lighter weights. They have the same mechanism of transposition, only in the case of the two smallest, a little more simplified and less complete. In the centre of the large engraving (Fig. 3) are seen the large arms of the lever which allow the weighings to be made at a distance. These arms rest on three stone pillars, above which are placed the telescopes for reading the oscillations of the beam.

The following are some details of the mechanism of transposition employed in this balance. The pans of the balance have a shape altogether peculiar. Each is formed by a circular piece open at one point and extending itself inwards by four triangular plates or teeth directed towards the centre of the balance. A cross piece placed underneath can be passed between these plates. Suppose now that weights, say of one kilogramme each, are placed above the pans on each side; and to make the idea the more definite let the kilogramme A be on the left scale and the kilogramme B on the right. Taking hold of one of the four handles under his hand, the observer sets the mechanism in motion. This is what happens:—the cross piece placed under the pan mounts at first, ascends beyond the plane of the pan and consequently lifts the kilogramme resting above it. Arrived at a suitable height the cross piece shifts its place laterally, and disengaging itself from the pan it gradually gets deposited above one of the plates, attached right and left to the pillar of the balance. These plates follow an arrangement analogous to that of the pans. By continuing the movement the cross piece then commences to descend, and traverses the plane of the plate, depositing on it the kilogramme which it has raised from the scale. While these movements are effected to the left in the case of the kilogramme A, they are in simultaneous accomplishment to the right in the case of the kilogramme B. The two weights to be compared are thus transferred at the same time to the central plates. Then taking hold of a second handle the observer turns the two plates 180° round the axis of the pillar of the balance, a movement which shifts the plate which was at the left to the right, and conversely. All that is needed then is to cause the same evolution to be gone over again with the crosses which they have already done, but inversely, in order to bring back the kilogrammes to the scales of the balance; the kilogramme A is then at the right, the kilogramme B at the left, and the observer can proceed to the second part of the weighing.

The two other handles control—one the movement serving to release the pans, the other the movement lowering the fork and setting free the beam.

For a long time it has been known that the balance is an instrument of precision *par excellence*. By means of those here in question the minimum amount of error in the process of weighing has been reduced to an almost infinitesimal degree. The difference of two kilogrammes, for example, can by them be determined to a nicety reaching to the hundredth of a milligramme, that is, the weight of a kilogramme is ascertained down to within a hundred millionth of its absolute value.

In another part of the hall is shown the hydrostatic

¹ Continued from p. 466.

balance serving to determine densities; and here, again, details of operations have been perfected up to the last limits compatible with the actual state of science. The water which is to be used for hydrostatic weighings, having been once distilled by an ordinary still, is redistilled by means of an apparatus of platinum, and then re-collected in a platinum vase. The latter is placed under the balance employed for the weighings, and by a series of ingenious apparatus the weights can be plunged in the water and all the manipulations performed,—manipulations often very delicate, but indispensable if all possible chances of error are to be reduced to a minimum.

The weighing section contains, besides, a beautiful collection of weights,—in platinum, iridium, and in quartz for weights of the first class, and in gilt brass for weights of the second class.

Irrespective of the fundamental apparatus we have just mentioned, the bureau possesses a large number of different instruments; some intended for certain special labours, others necessary for accessory processes in close connection with operations of comparisons or of weighings. Among the former, one of the most remarkable, by reason of the exceeding delicacy of the method it sets in operation, is the Fizeau apparatus, by means of which expansions in small standards, or fragments of some millimetres in thickness, are measured by applying an optical process founded on observation of the phenomenon of the interference of light. This apparatus enables variations of distance between two points to be determined and measured down to some millionths of a millimetre.

The accessory instruments are cathetometers, spherometers, meteorological instruments, barometers, thermometers, hygrometers, &c. Fig. 4, for example, shows the normal barometer of the section of weighings, a splendid instrument combining all the most perfect contrivances for the measurement of atmospheric pressures with the utmost possible degree of accuracy.

The measurement of temperature plays an essential part in all operations which have to be performed with standards either of length or of weight; the studies in connection with the thermometer have likewise a place so important that they may be regarded as constituting a section by themselves, with instruments peculiarly their own.

The measurement of temperatures does not form a separate section in the International Bureau, but the importance of the operations connected with it and the precision of the apparatus employed for this end entitle it to a special description.

The air thermometer depends on a remarkable principle, the knowledge of which science owes to the classical experiments of Regnault on the expansion of gas. The illustrious physicist has in effect demonstrated that the increase of tension which gas suffers when heated while its volume is kept constant is sensibly proportional to the temperature.

It is easy to conceive that Regnault utilised this property for the measurement of temperatures. The first air thermometer of precision constructed by him consisted essentially of a glass globe filled with air, connected by a capillary tube with one of the arms of a mercurial manometer. Special contrivances allowed the mercury to be constantly maintained at the same height in this arm, while the globe was exposed to different temperatures. The tension of air at each temperature is then measured by the height of the mercurial column balancing it.

This instrument, generally employed by experts, has subsequently undergone numerous modifications, the most of which aim at imparting greater precision to the measurement of pressures. This measurement, which consists in determining the difference of the height of the mercurial level in the two arms of the manometer, really presents great difficulties, seeing that tubes of large dimensions are employed for the manometer, a condition

necessary to avoid the capillary depression of the mercury. The surface of the mercury in the large tubes presents a plane superficies, so smooth that it is impossible to distinguish the level of the mercury when it is viewed horizontally. To attain this end, one makes use of movable points, bringing them gradually close to the surface. Observing, then, in a telescope the level of the mercury, the point is seen drawing nearer and nearer its image; the instant of contact between the movable point and its image indicating exactly the level of the mercury.

The apparatus represented in Fig. 4 is the one which has been constructed at the observatory of the International Bureau. The arrangement we have just spoken of has been adopted as much for the sake of the readings of the manometer as of the measurement of the atmospheric pressure in the normal barometer, B B. In the part to the left of the diagram, one distinguishes in A the arm of the manometer which is connected by a capillary tube with the globe placed in the interior of the warming apparatus. The latter has been placed in an adjoining position, in order not to expose the measuring apparatus to variations of temperature.

Having determined the normal positions of the instruments, one can proceed to the comparison of the mercurial thermometers, *t*, the reservoirs of which are placed in the warming apparatus in proximity to the globe, A, of the air thermometer. The observations consist in reading on one side the temperature indicated by the mercurial thermometers, and on the other in measuring the difference of the mercurial level in the two arms of the manometer; the open arm of the latter experiences the atmospheric pressure, the manometer merely indicating the difference between the atmospheric pressure and the tension of air inclosed in the globe. To get the total pressure balancing the tension of the air in the globe, the barometric pressure must be added to that indicated by the manometer. The measurement of the pressures is effected by means of three horizontal telescopes, movable vertically through the length of the upright fixed to the pillar shown on the left side of the diagram. This upright is able to turn on its axis. Having adjusted the level of the mercury, one can turn the telescopes, without deranging them, round this vertical axis in such a manner as to read the graduations on the scale attached to the adjacent manometer. The telescopes fixed on the upright form to some extent, a pair of beam compasses, as they allow the difference of the mercurial level in the arms of the manometer to be transferred to the scale serving to measure it.

These instruments are easily adequate to the measurement of a hundredth of a millimetre. In the ordinary conditions of experiments three hundredths of a millimetre correspond with a variation of temperature of one hundredth of a degree Centigrade. To maintain the temperature constant within these limits, the steam of different liquids, such as water, ether, methylic alcohol, ordinary alcohol, the ebullition of which takes place at continuous temperatures, is used with advantage. The regular ebullition of these liquids being one of the conditions essential to the constancy of the temperature, the arrangement indicated in the diagram has been decided on. A vessel, *a*, placed in a water-bath, *c*, contains the liquid, the steam of which escaping by the tube *x*, penetrates into the double cased heating apparatus. Having traversed all the parts of the apparatus, including the glass tubes in which the mercurial thermometers *t* are placed, the steam issues by the tubes *y* to liquefy in the condenser R, whence the liquid returns to the vessel by the tubes A. Other tubes serve equally to return to the vessel so much of the steam as becomes condensed on the way or in the apparatus, so that the same quantity of liquid will serve for a sufficiently long time. The water-bath *c*, which supplies the heat necessary for keeping up the boiling of the liquid employed, is itself heated by

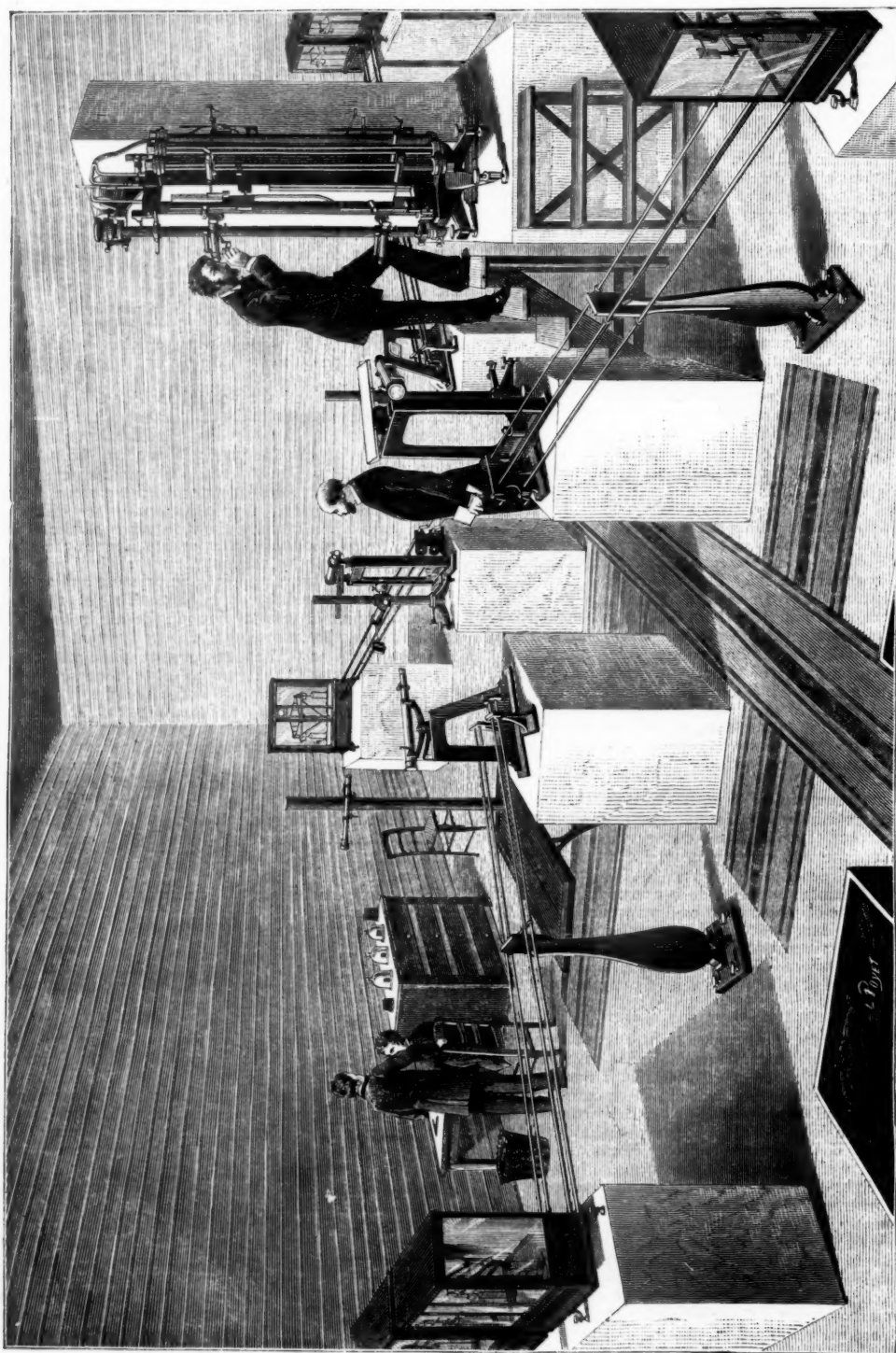


FIG. 3.—General View of the Great Hall of the Observatory.

Oct. 18

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the steam from a little copper, *f*, placed at some distance from it.

The arrangements we have just briefly described enable a difference of readings between the air thermometer and the mercurial thermometer to be determined to nearly the hundredth of a degree.

From the descriptive summary thus given it will be seen how important is the new and remarkable international establishment now really established in the neighbourhood of Paris. It remains to add a word regarding the benefits which the labours of this institution are calculated to yield and the phases they have actually assumed.

The signing of the Metre Convention of 1875 will necessarily be followed in the near future by the adoption of the metric system on the part of all the nations of the civilised world. The universal introduction of a uniform

system of weights and measures, by establishing a new bond between people and people, and by promoting international relations, will undoubtedly prove a powerful factor in the interests of civilisation. This, however, is not the only, nor even the principal, interest of this international work. It was not necessary, it may be properly asserted, for the purposes of commerce and industry, to create a collection of such complex and perfect instruments and machines. More than anything else the interest of the labours of the bureau is scientific. Science will more and more cease to rest content with close approximations; in all possible branches it craves rigorous exactitude, it aims at precision. The International Bureau will furnish science not only with standards of measurement exactly controlled and verified, but also with a great number of physical constants determined with the greatest care and under conditions as perfect as possible.

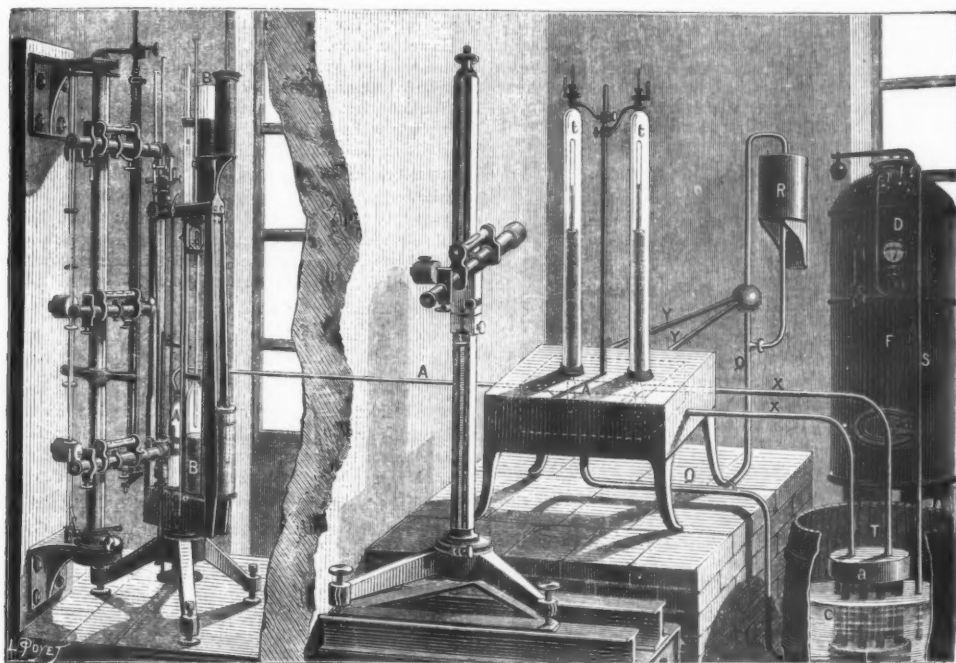


FIG. 4.—Apparatus for Measurement of Temperature and Barometric Pressure.

Among all the sciences the one which will reap the greatest benefit from the new institution is geodesy. In fact one of the greatest drawbacks to an exact knowledge of the figure of our globe is just the uncertainty still prevailing in regard to the relative values of the measures which, having been employed for the measurement of the different bases, have served as points of departure for triangulations executed on various points of the earth's crust. The minute study of these measures, centred henceforth in the laboratories of Breteuil, will assuredly cause the troublesome discrepancies to vanish, and will offer a surer basis for the labours of geodesists. As much may be said of the study of the variations of gravity by means of the pendulum. The International Commission have decided on taking as the point of departure for the new metric units the standards already existing, that is, the metre and the kilogramme of the archives of France in their actual state. This decision ought to receive unqualified approval. While rendering full homage to the great and valuable

idea, formed at the end of last century, that the basis of universal measurements must be sought in the dimensions of the globe occupied by the human race, it ought also to be understood that for the present day the pith of the matter does not centre in the metre being a few microns (millionths of a millimetre) longer or shorter. The great point is that the whole world possess the same metre, and that the copies distributed be all perfectly equal to the standard, or rather rigorously determined in relation to that standard. To demand over and above that the length of the metre tally exactly with its theoretic definition would assuredly be demanding that the metre be subjected to periodical retouchings and modifications in order to make it keep pace with the progress of science, which would be the very worst of inconveniences for a fundamental unit.

This point settled, the next thing was to make an international metre and kilogramme,—copies, viz. as exact as possible of the metre and the kilogramme of the archives,

but presenting a greater guarantee than the originals in regard to their indefinite conservation and precision of comparisons, and which, being the common property of all the signatory nations of the Convention, should be preserved at the International Bureau, and serve henceforth as prototypes and points of departure in the system of weights and measures for the entire world.

The task next following was to make a sufficient number of metres and kilogrammes for distribution among the contracting Governments, after they had been compared with the international standards.

The choice of the material of which the new standards should be constructed, the form to be imposed on them, the nature and arrangement of the designs, the processes to be employed in the comparisons, and a host of accessory questions connected with the preceding matters—have all been the subject of long and learned deliberations, in which, besides the International Committee, the French section of the International Commission, composed of the best qualified French authorities, have played a great part. Even with the utmost possible brevity it would take too long to pass each of these points in review. Suffice it to say that the material adopted for the new standards, as much for the metre as the kilogramme, is platinum alloyed with a tenth part of iridium, which will impart to it greater hardness and resistance. The labours which the choice of this material has called forth have given rise to remarkable improvements in the mode of working and purifying the platinum and the metals with which it is found allied in the ore. It is impossible to recall them without at the same time bringing to remembrance Saint-Claire Deville, who with indefatigable zeal devoted the last years of his life to this pursuit.

The form fixed on for the metre is that of a bar, the section of which has the shape of an X or rather an H, the legs of which would straddle towards the top and towards the bottom. This form, calculated to supply a maximum rigidity for a given quantity of material, offers various other advantages on which we cannot now enlarge. It is 1.02 m. in length, and on the upper surface of the transversal limb (that is, on the neutral surface of a deflected beam) are traced two very fine lines, the distance of which at zero represents just the length of the metre. It is then a *metre à traits*. The metre of the archives, on the other hand, is a *metre à bouts*, that is, a bar measuring from one extremity to the other exactly the length of a metre. The metre is then defined by the distance at zero between the middles of the two terminal planes.

The comparisons between the international metre and the metre of the archives have been made at the *Conservatoire des Arts et Métiers*; those between the international kilogramme and the kilogramme of the archives have been made at the *Observatoire*. These labours, lasting no less than several months, have been performed by the care and under the direction of a mixed Commission composed of members of the International Committee and of members of the French section, under the presidency of M. Dumas, perpetual secretary to the Academy of Sciences, which represents France on the Committee. The fabrication of the national standards is in course of execution, and the definitive comparisons will shortly be able to be entered on.

NOTES

We regret to announce the death of Dr. Oswald Heer of Zurich, the well-known palæontologist, at the age of seventy-five years. In his earlier years Dr. Heer devoted himself to entomology. We hope to give some notice of his life and work in our next number.

THE works in connection with the erection of the Ben Nevis Observatory are so far forward that the formal inauguration of the

Observatory was to take place yesterday. With the view of stimulating public interest in the Observatory, there has just been published a small handbook giving an account of its origin and describing the objects it is intended to promote. Mr. George Reid, R.S.A., has contributed attractive drawings of Ben Nevis from the sea, and of the Observatory building; from Dr. Archibald Geikie have been obtained bird's-eye views of the scenery visible from the mountain top; and there is also inserted an excellent map, in which the new bridle-road is laid down and the configuration of the district indicated by numerous contour lines. From a statement given as to existing high-level meteorological stations in other parts of the world, it appears that America maintains two such posts—namely, Pike's Peak, 14,131 feet, and Mount Washington, 6286 feet; while France can claim four, ranging from 3989 to 12,199 feet; and Italy three, of which the highest is 8386, and the lowest 7087 feet. Russia has one as high as 3787 feet, and Switzerland two, of 7505 and 2875 feet respectively. The highest in this island, so far, would seem to be Hawes Junction, 1135 feet, and Dalnaspidal, 1450 feet. Ben Nevis gives an elevation of 4406 feet, and, as has been repeatedly explained, important results are expected from the comparisons it will enable meteorologists to make between the state of the atmosphere at that height and the conditions prevailing at sea level. No time will now be lost in commencing the work of the Observatory, which has been intrusted to Mr. R. T. Omond, with Mr. Angus Rankin, and another yet to be appointed, as assistant observers. During the winter months the summit of the Ben may for weeks together be inaccessible; but certain observations will be daily communicated by means of the telegraph now being laid by the Post Office.

THE announcement of the publication of the Berlin Catalogue of Zonal Stars will have the effect of postponing the publication of the French catalogue, for which a credit of 400,000 francs had been asked from the Budget Commission.

THE President of the Berlin Geological Society has received a telegram from the Pentland Firth announcing the safe return of the German schooner *Germania*, which carried the German Polar observing party from the Gulf of Cumberland, where it has spent a year in successful observation and research.

WE have received a telegram from Herr Augustin Gamél of Copenhagen, in which he informs us that the *Dijmphna* anchored at Vardö, Norway, on October 11, all being well on board.

THE Russian Geographical Society is taking an active part in the International Congress which is to be convoked by the United States for the unification of the meridian. Delegates from the Academy of Sciences and from the Russian Ministries of War, and Posts and Telegraphs, will constitute a Committee at St. Petersburg, and the conclusions of this Committee will be supported at Washington by one or more Russian delegates.

WE learn from the annual reports of the West Siberian and East Siberian branches of the Russian Geographical Society (published in the *Izvestia*) that the East Siberian branch busily continues the exploration of the very rich remains from the stone period around Lake Baikal. The valley of Tunka, which seems to have been an immense workshop for the fabrication of quartz, jade, and nephrite implements, has been visited again by M. Vitkovsky, as well as the valley of the Angara. This last consists of a succession of large plains separated by narrow gorges; the former was occupied during the Post Pliocene period by a series of lakes, and subsequently it was the abode of a numerous population of the Stone period. M. Agassiz discovered also a place on the Steppe of Ust-Unga which must have been a large work-shop for the fabrication of stone implements, pieces of which cover the steppe over a space of more than twelve miles; thousands of implements could be collected

on the steppe. It is worthy of notice that the stone hatchets of the steppe are quite like the stone implements of the Chukches. The West Siberian branch continues the exploration of the less known parts of Western Siberia, and the last volume of its *Memoirs* contains several interesting papers:—On the Altai, by M. Yadrinseff; and on the Naryn region, its inhabitants, and their trades, by MM. Grigorovsky and Shostakovich.

PROF. NORDENSKJÖLD has presented a meteoric block, which he found in 1870 at Greenland, to the Helsingfors University, where it has just arrived from America. Its size is not great, only one foot in height, but it is very heavy. It bears the following inscription in English: "Terrestrial native iron. Ovipak, Greenland. Brought by A. E. Nordenskjöld." In presenting this unique specimen to the University the Swedish explorer writes:—"During my journey to Greenland in 1870, I found at Ovipak, on the Disco peninsula, several large blocks of iron which were brought home the year after by one of the naval steamers. On arriving there they were equally divided, as far as possible, into three parts, of which one became Swedish, the other Danish, and the third my property. To the latter belongs the block which I present to you, its weight being about 10,000 lbs. The same has, since 1876, when it was exhibited in Philadelphia, been deposited in Washington. As may be generally known, a fierce controversy has raged as to the nature of these blocks, some authorities maintaining that they were of meteoric, others of terrestrial, origin, a question on which opinions certainly may be divided. However this may be, it is certain that these blocks, whether as a specimen of the cosmic matter in the universe, or of the earth's interior, are of exceptional interest, and may be considered to be valuable gems in any museum. To me personally this discovery is enhanced in value, as it enables me to present a testimony of my gratitude and affection to the institution where I received my first scientific education, and passed the most important period of my life." The block is to be kept out in the open air, as it has been discovered that these stones waste away in a room.

MR. D. MORRIS has in the press a work which will be shortly published, entitled "The Colony of British Honduras, its Resources and Prospects; with Particular Reference to its Indigenous Plants and Economic Productions." This work will include the results of Mr. Morris's travels in British Honduras, and throw a new light on many points connected with the climate, the flora, and the resources of this little known British dependency. The publisher will be Mr. Edward Stanford.

MESSRS. W. H. ALLEN AND CO. will publish shortly "The Influence of the Sun on Natural Phenomena," by A. H. Swinton, author of "Insect Variety."

THE green sun referred to last week as observed in India was also observed in every part of Ceylon from September 9 to 12. One correspondent writes as follows to the *Ceylon Observer*:—"Puleaderakam, September 12.—I write this from the above place on my way to Trincomalee, being much interested to learn whether the same phenomena exist throughout the island. The sun for the last four days rises in splendid green when visible, i.e. about 10° from the horizon. As he advances, he assumes a beautiful blue, and as he comes further on looks a brilliant blue resembling burning sulphur. When about 45° it is not possible to look at it with the naked eye; but, even when at the very zenith, the light is blue, varying from a pale blue early to a bright blue later on, almost similar to moonlight even at midday. Then, as he declines, the sun assumes the same changes but *vice versa*. The heat is greatly modified, and there is nothing like the usual hot days of September. The moon now visible in the afternoons looks also tinged with blue after sunset, and as she declines assumes a most fiery colour 30° from the zenith. The people are in terror at these phenomena, some even expecting the end. Can this be the result of the eruption in the Sund

Straits?—P.S.—There is no light even though the sun is visible until nearly 7 a.m."

A TERRIBLE earthquake occurred on Tuesday near Cheshmeh, a small town on a peninsula on the coast of Anatolia, and about twelve miles from the Island of Scio. Of late there have been several earthquake shocks in the pashalic of Anatolia and in other parts of Asia Minor, but it is to be feared that Tuesday's event eclipses all recent shocks in the devastation it has caused. It appears that the whole peninsula, from Smyrna to Cheshmeh, together with the neighbouring Island of Scio, was violently convulsed. The greatest destruction has been wrought in the western half of the peninsula between Cheshmeh and Voulra. All the villages in this district are destroyed, being nothing more than heaps of ruins. The wretched inhabitants had no time to escape, and upwards of 1000, it is estimated, have perished, while many others are injured.

AT 11.20 p.m. October 9 a slight shock of earthquake was felt at Irkutsk, Siberia. Several shocks of earthquake were felt on the 10th in the afternoon throughout the whole of Northern Moravia. The oscillations lasted on each occasion from one to two seconds. The most violent shock occurred at Olmütz. Telegrams from Cilli, in Southern Styria, show that there were severe shocks felt there about an hour earlier than at Olmütz. On the same morning, too, there was a shock at Agram, lasting two seconds. A strong shock of earthquake, lasting fully eight to ten seconds, was also felt at Chios. The shock was felt at Syra, on the Dardanelles coast, and at Smyrna.

A WELL attended meeting of science and art teachers was held at the Birmingham and Midland Institute on Saturday last. On the motion of Prof. Tilden (who presided), seconded by Mr. E. R. Taylor of the Birmingham School of Art, it was resolved "That in the opinion of this meeting it is desirable to establish for Birmingham and the district a branch of the National Association of Science and Art Teachers." Among the objects of such an association it was mentioned would be the improvement of science and art teaching by discussions of methods of teaching and modes of demonstrating important scientific laws. A provisional committee was appointed, with Mr. C. J. Woodward as honorary secretary.

PRINCIPAL DAWSON asks us to state that in our report last week of his paper at the British Association (p. 579), the word *relatives* in the title should be *relations*, and that not *tin* ore but *iron* ore occurs in the Laurentian.

THE additions to the Zoological Society's Gardens during the past week include a Ruppell's Parrot (*Psephenops ruppelli* ?) from East Africa, presented by Dr. George L. Galpin; a Malabar Parakeet (*Psaltriparus columboides*) from Southern India, presented by Mr. F. W. Bourdillon; two Pileated Jays (*Cyanocorax pileatus*) from La Plata, presented by Mrs. J. W. Hammond; two Buzzards (*Buteo vulgaris*), a Hobby (*Falco subbuteo*), European, presented by Capt. H. Linklater; a Tiger Bittern (*Tigrisoma brasiliense*) from South America, presented by Mr. Joseph H. Cheetham, F.Z.S.; a Turtle Dove (*Turtur communis*), captured at sea, presented by Mr. W. M. Brown; five Long-nosed Vipers (*Vipera ammodytes*), a Viperine Snake (*Tropidonotus viperinus*), European, presented by Lord Lilford, F.Z.S.; a Macaque Monkey (*Macacus cynomolgus*) from India, a White-fronted Capuchin (*Cebus albifrons*) from South America, a Michie's Tufted Deer (*Elaphodus michianus* ♂ & ♀), an Elliot's Pheasant (*Phasianus ellioti* ♂) from China, deposited; two Eyras (*Felis eyra*), a Red-vented Parrot (*Pionus menstruus*) from South America, a White-fronted Amazon (*Chrysotis leucophaea*) from Cuba, two Royal Pythons (*Python regius*) from West Africa, purchased; a Collared Fruit Bat (*Cynonycteris collaris*), born in the Gardens.

THE MOVEMENTS OF THE EARTH¹

I.—Measurement of Space

IN proceeding to deal with the application of the various branches of physical science to the investigation of those phenomena which lie beyond the earth, there is a very large field from which to make choice of a subject which will show, now the application of one branch of science, and now the application of another, and bring us, in this way, somewhat nearer to the truths and the beauties which lie in the most distant realms of space for all who will take the trouble to look for them. But perhaps it may be more desirable to select that part of the subject which, so to speak, lies nearer home, and endeavour to point out how, by means of the application of principles, and methods, and instruments which are generally familiar, and which at all events are of daily use, the various movements with which our planet is endowed may be studied, not only with reference to the phenomena themselves, but with reference also to the causes which lie at the bottom of them.

The various branches of knowledge which will have to be drawn upon in furnishing the materials necessary for this inquiry were really started long before it was imagined that the earth had any movements at all; but still, on the whole, the growth of the knowledge of its movements has been so beautifully continuous, that we cannot do better now than consider historically the way in which those sciences have grown up, which enable us to make certain measurements, and to get out correctly certain quantities, which must necessarily lie at the bottom of any sound knowledge.

What particular things do we want to measure? It has been already said that when the sciences to which attention will have to be called later on were founded, very few people on this planet knew that it moved at all, but it is now generally known that the earth does move. It will be obvious however that, whether the earth moves or not (and that may be considered still a moot question), if we wish to form a basis for our judgment in any direction, we must be able to measure time and space. It has been well said that "time and space are the moulds in which phenomena are cast;" for when it is desired to gain any useful knowledge concerning any fact, the relation which it bears to the things around it, and the time of its occurrence must be known, and that is the only thing an astronomer tries to do when he is investigating that portion of his subject to which we must first turn our attention. We will begin then by considering those measurements of space which are of the first importance to the astronomer. I do not here refer to the ordinary familiar measurement of inches, yards, and miles, but to the measurement of angles, and it will be well to get a good notion of this angular measurement as soon as possible.

There is no special necessity for dividing the circle into 360 parts, but the greatest number of people have made that division, and it is still continued to be done. When the Chinese began to make circles they divided them, not into 360 parts, but into 365. Now there was a great advantage, and a great disadvantage about that. The advantage was that this number of divisions in the Chinese circle was the same as the number of days in the year; the disadvantage was that they were not dealing with whole numbers, and their 365 was not such a convenient number to halve and quarter, and so on, as is 360. In quite recent times it has been suggested that 400 parts should be taken instead of 360, but that is a suggestion which up to the present time has not been acted upon.

We have then an angle defined as the inclination of two straight lines starting from a centre; if we get one of these lines traversing an entire circumference, the other remaining at rest, the travelling line will have traversed 360°; we have what is called a right angle when one of the lines has been separated from the other through a quarter of a circumference—that is, 90°. This is the fundamental idea of angular measurement, the only measurement of space with which we shall have to deal at present.

For instance, if a little ivory rule be opened, its two parts become inclined to each other, and inclose what is known as an angle. That angle may be made large or small by opening and closing the two parts, A and B (see Fig. 1) of the rule. Suppose the rule to be shut, the point on which it turns being in the centre of the circle, CDEF, and that, whilst A remains at rest, B is made to travel successively

through B and B' to B². It will then have travelled half the circumference of the circle CDEF, but civilised people, in order to get perfectly clear notions about this measurement, and to be able to tell each other what particular measurement they have made in this way, instead of talking of a circumference merely,

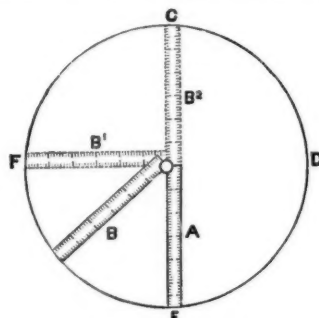


FIG. 1.—Use of a two-foot rule to explain angular measurement. With the part A at rest, the movement of the other to B, B' and B² gives us 45°, 90°, and 180°.

and of certain rough divisions of it, have divided all circles into 360 parts called degrees, and say that the travelling part, B, of the rule has travelled through not a quarter, or a half circumference, but through 90 and 180 degrees respectively.

Why are these measurements of space required? For the reason that when we are dealing with the heavenly bodies and seeking to define the position of any object, two facts at least are required to be known before its exact position can be determined. An observer going out at night upon an extended plain would see some celestial bodies near where the earth meets the sky all round, which is called the circle of the horizon, and he might happen to see another body exactly overhead, in what is called the zenith. In passing from this zenith to the horizon it will be obvious that a quarter of a circumference is traversed (see Fig. 2). That distance may therefore be divided into 90°.

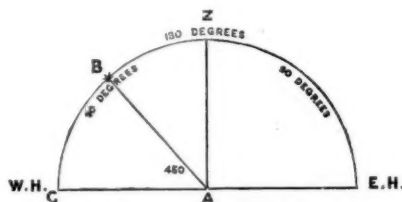


FIG. 2.—Measurement of altitudes.

Similarly in passing from the eastern horizon to the western horizon half a circumference is travelled over. This distance therefore is divided into 180° of angular measurement in the same way that the half of the circumference traversed by the travelling rule was divided into 180°.

Now if it can be ascertained of any body that it is exactly in the zenith, the position of that one body has been definitely stated for the particular time at which the observation is made. But consider the case of another body not in the zenith. Suppose that the lines, the one AB (see Fig. 2), passing from the observer to the object, and the other, AC, passing from the observer to the horizon, inclose an angle of 45°. This angle is called the star's altitude. But to say simply that the altitude of a star is 45° does not sufficiently define its position. Let the reader imagine himself to be standing in the Albert Hall. He knows that he may look up and see rows of panes of glass and ornamented work running around the hall at different heights above the floor. He may also notice, let us say, various series of ornamentation arranged vertically from floor to roof. Now suppose it were desired to define the position of any one pane of glass or piece of ornamentation in any one of these horizontal or vertical rows. It is obvious that to say of any pane of glass at one level that it is at a certain height above the floor will not suffice, for all the panes of glass in that row are at the same

¹ Report of Lectures to Working Men given at the Royal School of Mines by J. Norman Lockyer, F.R.S.

elevation. In like manner in defining the position of any one piece of ornamentation in the vertical series it will not be sufficient to say that it is at a certain angular distance from any one point, say a door, because all the pieces in the same row are at this angular distance from the door. But if these two methods of stating position be combined, if the height above the ground as well as the angular distance from the door be given, then a definite statement may be made both of the position of the pane of glass and the piece of ornamentation. Similarly with the stars. Imagine a horizontal circle passing from north to south, and thence to north again. A line from the zenith through any body will cut this circle at some one point, and the number of degrees included between that point and the north point will give the angular distance from the north point, or, as it is called, the azimuth. The whole of an imaginary line of bodies extending from the zenith to the horizon will have the same azimuth (see Fig. 3). In the same way we may imagine a whole ring of bodies

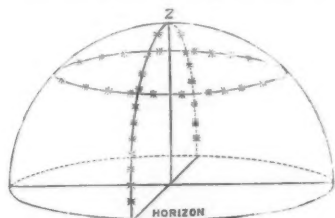


FIG. 3.—Stars with equal altitudes and stars with equal azimuths.

at the same height above the horizon, having the same altitude (see Fig. 3), but a particular altitude and a particular azimuth can be true of only one of those bodies. It is in this way, then, by a statement of the altitude and azimuth, that the position of a star or other celestial body can be indicated with reference to any one particular place of observation and any one particular instant of time.

It is by thus dealing with this angular measurement that the exact positions of the heavenly bodies have been determined.

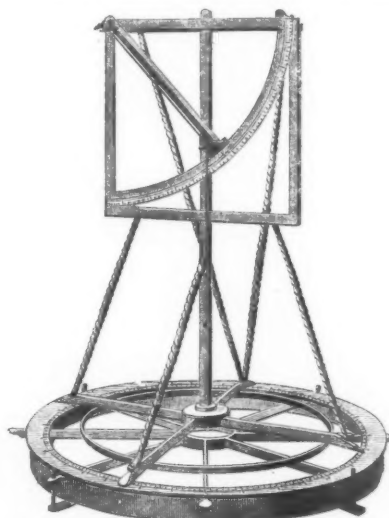


FIG. 4.—Tycho Brahe's altitude and azimuth instrument.

This point has been discussed at some length, because in making an historical survey it will be found, that the growth of that particular knowledge of which we shall come to speak, has been the growth of man's capability of getting finer and finer in this angular measurement. To go back to the time of the old Greeks, Hipparchus, one of the most eminent of ancient observers, even in his day could define the position of a heavenly body to within one-third of a degree. Since these 360 degrees

into which circles are divided are each subdivided, first into 60 minutes, and each of these again into 60 seconds, the one-third of a degree to which Hipparchus attained may be called 20 minutes of arc.

Passing from his time to the middle ages, a most interesting instrument then in use claims attention. Fig. 4 is a copy of a photograph of the instrument.

The model, from which the photograph has been taken, is an exact copy of an instrument made by one of the most industrious astronomers that ever lived, Tycho Brahe, and shows how, even in the very beginning of this observational science, men got at a very admirable way of making their observations, considering the means they had at their disposal. First there was in this instrument a quadrant of a circle (see Fig. 4), which served their purpose just as well as a whole circle. Combined with this was an arrangement somewhat resembling the "sights" on a modern rifle. Remember this was before the days of telescopes. So they started with these sights and a little pinhole, that they might take a shot, as it were, at a heavenly body, putting the eye near the pinhole, and seeing the heavenly body in a line with the front sight. Then the instrument was provided with a plumbline to show the vertical. This plumbline was so arranged that when the sight lay along it, a body in the zenith would be observed, and an angle of 90° altitude recorded. With the instrument thus set, any smaller altitude could be read along the quadrant, according to the position of the line of sight passing through the eye, the centre of the quadrant, and the place of the heavenly body.

To get azimuth they used a horizontal circle, shown at the base, also divided into degrees and provided with a pointer. By sweeping the instrument round until the azimuth was such that the body was seen through the pinhole, and the altitude was such that it was seen in a line with the front sight, they fixed its position, as well as that instrument enabled it to be done. Supposing that their circles were properly divided, it was quite easy to determine a division as small as the quarter of a degree. This would put Tycho Brahe in only a little better position than Hipparchus. That is to say, from the time of the Greeks until about the middle of the fifteenth century, the only advance made with this angular measurement, was that a reading of one-third was improved into a reading of one-fourth of a degree.

Another notable improvement and advance towards a finer and more accurate measurement was made by Digges. He introduced the diagonal scale, the principle of which is shown in Fig. 5. The arrangement consists of a number of concentric



FIG. 5.—Digges' diagonal scale.

circles, in this case nine. The distance between the divisions of the inner circle is $3'$. From each of these divisions diagonal lines are drawn to the outer circle in such a manner that the diagonal cutting the first circle at $0'$ cuts the ninth circle at $3'$. That cutting the first circle at $3'$ cuts the outer circle at $6'$. So with the other diagonal lines. Consider the diagonal passing from $0'$ on the inner circle to $3'$ on the outer. If the pointer cuts the scale at the former point, an observation of $0'$ will have been made; if it cuts at the latter point, an observation of $3'$ will have been made. But it may cut the scale at some intermediate point. Suppose it falls on the eighth of the nine concentric circles, then the value of the observation will be $7/8$ ths of $3'$. Should the pointer fall half way between $0'$ and $3'$, the reading

will be $\frac{4}{8}$ ths of 3° . So with the other intermediate points. In this way, then, Digges enabled a much greater accuracy to be attained in this circle reading.

The next great improvement after that of Digges was one made by M. Vernier, a Frenchman, who, in about the year 1631, invented the instrument which bears his name. The following is the arrangement. Let the scale on which the measurements are made be divided into a certain number of parts. Take a second



FIG. 6.—Vernier reading to tenths of divisions.

scale called the vernier, shorter than the first by the length of one of its divisions, and make the number of divisions in this vernier equal to the number of divisions in the scale. Then each of the divisions of the vernier, will be less than each of the parts of the scale, by a fraction having one for its numerator, and the number of divisions in the scale or vernier respectively for its denominator. Thus if the number of divisions be ten (see Fig. 6), and the vernier equal in length to nine of such

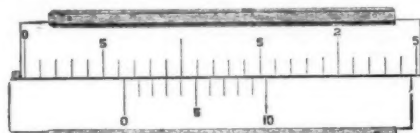


FIG. 7.—Vernier shown in Fig. 6 reading to three-tenths.

parts has also ten divisions, each of these divisions will be shorter by $\frac{1}{10}$ th than each of the parts of the scale. If the number of divisions be seventeen (see Fig. 8) the different parts of the vernier will be less by $\frac{1}{17}$ th than each of the divisions of the scale. So when the number of divisions is thirty (see Fig. 9), the parts of the vernier will be less by $\frac{1}{30}$ th than the divisions of the scale. The arrangement, however, is not limited to straight scales. It may also be used for the determination of small

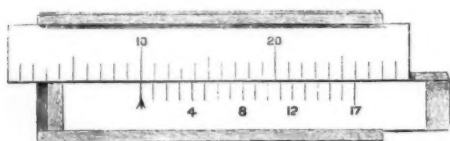


FIG. 8.—Vernier reading to seventenths.

fractions of degrees on a circle. Fig. 10 represents a vernier giving tenths of degrees on a circle. It need hardly be said that the vernier may be constructed to give readings upon the inner as well as the outer edge of the graduation.

In using the vernier the observer looks along it until he meets a coincidence, that is for a point where one of the divisions on the scale coincides with a division on the vernier. If this occurs at the eighth division, then the observation is some whole num-

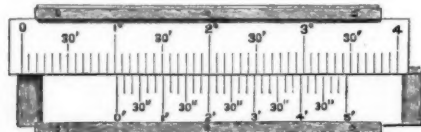


FIG. 9.—Application of vernier to circle reading to one-tenth of a degree.

ber, and $\frac{8}{10}$ ths, $\frac{8}{17}$ ths, or $\frac{8}{30}$ ths, according as the scale used is divided into ten, seventeen, or thirty parts. In Fig. 7 the coincidence occurs at the third division; the reading in that case would be some whole number and $\frac{3}{10}$ ths.

To the instrument of Tycho Brahe, then, the vernier, which can be adapted to it, has now been added. Of course by taking divisions enough the measurement may be made as fine as pos-

sible. A vernier of 100 divisions may replace the vernier of 10, of 17, or of 30 divisions. Seventeen divisions have been chosen to show that the principle is not limited to tenths. Any number of divisions may be taken. A very fine degree of accuracy can be attained then in angular measurement, owing to the introduction of the vernier, and that is why there is what is practically a vernier upon almost every measuring instrument in every workshop and laboratory. The question next arises whether with the introduction of the vernier the limit of accuracy has been reached, or whether it be possible to go beyond this. A negative reply may be made to this question. The

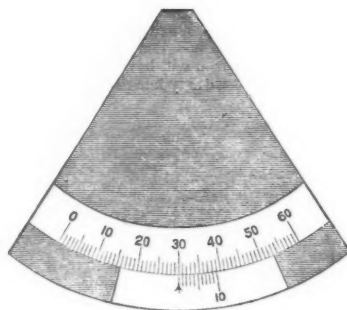


FIG. 10.—Application of vernier to circle reading to ten seconds of arc.

limit of accuracy has not here been reached. In order to get more accuracy in this angular measurement, it is only necessary to add some branch of physical science to those geometrical considerations by means of which circles have been so finely divided. The astronomer calls certain portions out of the science of optics, and uses them for his purpose. It is perfectly clear that the reason a limit is reached with an arrangement of the nature of the vernier is, that at last the divisions get so small that the eye cannot distinguish them, so that optical principles have to be appealed to to increase the power of the eye.

Before discussing this question of whether it be possible to

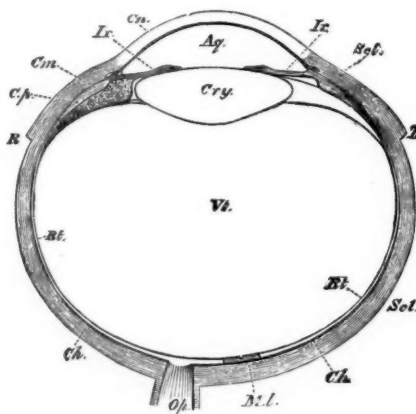


FIG. 11.—Horizontal section of the human eye.

select some principle of optics, by the application of which the power of the eye may be increased, it will be well to consider in what it is that that power consists. Fig. 11 will give a rough notion of those parts of the eye which specially relate to this matter. First comes the curved surface *Cn*, the cornea, and next *Ag*, the small anterior chamber which contains the aqueous humour. Behind this comes *Ir*, the iris, which limits the amount of light entering the eye, this being immediately succeeded by *Cr*, the crystalline lens. Then comes the large posterior chamber of the eye which contains the vitreous humour. Behind this the optic nerve enters the eyeball, ex-

panding itself into the delicate layer of nervous elements, *Rt*, which lines the inner surface of the vitreous cavity.

When any object is seen by the eye, the rays of light emanating from that body, impinging first upon the curved corneal surface, have to pass successively through *Ag*, *Cry*, and *Vt*, before they can affect the nervous retinal elements and cause the sensation of light. In passing through these portions of the eye, the rays of light are dealt with in a peculiar manner, especially perhaps by the crystalline lens, and are brought together to form what is called an image on the retina. This image influences the nervous elements of which the retina is composed in such a way, that a sort of telegram is sent to the brain through the optic nerve, and the brain becomes conscious of having seen something, the par-

ticular object seen being included in the message. Another diagram (Fig. 12) will perhaps make it a little clearer how this image on the retina is formed. At *AB* is an arrow; from it rays of light are marked going to the three different points on the retina. But it will be seen that those rays of light which come from the top of the arrow are, by the action of these three media, twisted downwards, and form an image of the top portion of the arrow on a low part of the retina. The rays of light proceeding from the bottom of the arrow are bent up, so that its image is formed on an upper part of the retina. The light coming from the middle of the arrow is not bent at all, and therefore forms its image on a middle portion of the retina. That is the way in which the eye deals with rays of light entering

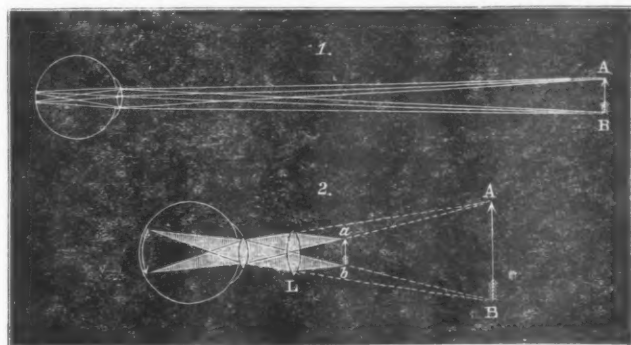


FIG. 12.—1. Diagram showing path of rays when viewing an object at an easy distance. 2. Object brought close to eye when the lens *L* is required to assist the eye-lens to observe the image when the object is magnified.

it. With this knowledge of the optics of the eye, it will be very easily seen how very wonderfully the construction of the eye has been imitated in a photographic camera. The front lens is practically the equivalent of those three refractive media of the eye, the aqueous and vitreous humours, and the crystalline lens; whilst the iris, which in the eye serves to limit the amount of light entering it, has its exact representative in the "stop," which serves the same end in the camera. The photographic plate is, it need hardly be said, the counterpart of the retina, and has consequently been beautifully described as "a retina which does not forget." Similarly there is just such an arrangement for focusing the light as exists in the eye. In fact a camera is a rather better machine altogether than the eye, because the range is greater, and the focusing power is not lost as age increases. Therefore the artificial eyes of our camera are never in need of spectacles.

1. *How Optics enables us to Read Fine Verniers.*—This knowledge, then, having been acquired, how is it to be utilised for the purpose of the measurement of angular space? It may be utilised in this way. The reason that we cannot clearly distinguish objects placed very close to the eye is, that the rays of light which flow from them are so extremely divergent that the crystalline lens cannot focus them on the retina. But by placing between the eye and the object a double convex lens, that is a lens like the crystalline lens of the eye, this extreme divergence is corrected; the crystalline lens is thus aided, and the rays of light are brought to a focus, as shown in the lower part of Fig. 12. Take the case of a vernier whose divisions are so fine that they are not visible at the distance of distinct vision, say about ten inches. If we attempt to correct this by making the divisions appear larger, by bringing the vernier close to the eye, we lose the power of focusing the rays which flow from it. But the introduction of a convex lens between the vernier and the eye enables the eye to see the division quite distinctly.

Of course the more nearly an object approaches the eye, the more powerful must be the lens, in order that the eye may clearly see it. In this way we see that the simple addition of a convex lens has enormously increased our power of observing and measuring small angles.

2. One can, however, go further than this, and use not one simple lens, but a combination of lenses. But before discussing the various combinations of lenses which are employed in various

instruments, it is necessary to look a little more closely than we have yet done at the structure and action of our convex lens. Let us use a glass lens in conjunction with an electric lamp. Then we may get an image of the carbon poles thrown on the

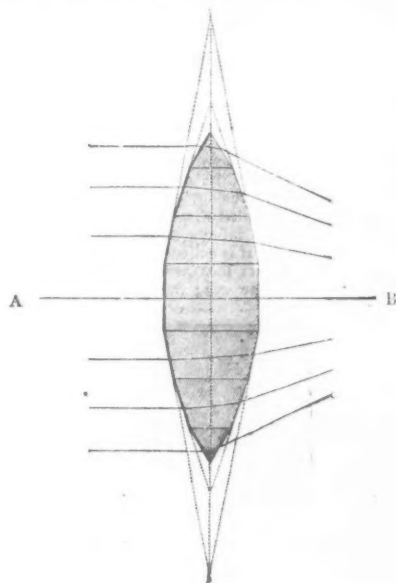


FIG. 13.—Formation of a lens from sections of prisms.

screen, in exactly the same way that the crystalline lens forms its image on the retina. But there would be this important difference, that while the image formed by the crystalline lens would

be a clear and distinct one, that formed by our glass lens would be a very bad one; instead of the poles of the electric arc being clearly and sharply defined, they would appear as if seen in a haze, and would be surrounded by coloured fringes of light, and not much could be made of them. Why is this? We find by experiment that this attempt to imitate the action of the eye by means of such a simple glass lens is an incorrect way of proceeding, the eye possessing certain qualities which the simple glass

lens does not. Although a lens seems to be a very simple matter, its structure is really based upon some very complicated considerations. If a section of it be taken it will be seen that its surface is built up of sections of triangular pieces of glass, these triangular pieces of glass being called prisms, and how they deal with the light it is very important for us to know. If in front of the beam of light issuing from the lantern a prism be interposed, it will be found that whilst part of the light is re-

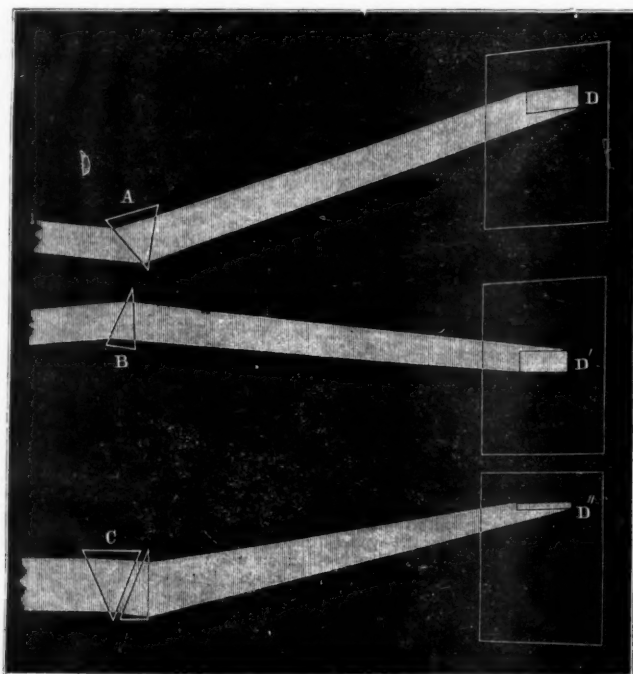


FIG. 14.—Diagram explaining the formation of an achromatic lens. A, crown-glass prism; B, flint-glass prism of less angle, but giving the same amount of colour; C, the two prisms combined, giving a colourless yet deviated band of light at D''.

flected from its first surface another portion is refracted as it is termed, that is, bent out of its original course by the prism. Further, it not only suffers this deviation due to refraction, but it undergoes also what is called dispersion. In fact, where the light falls on the screen an infinite number of different colours are seen, these forming what is called a spectrum. This is one of the reasons why such a glass lens as we have used will not perform the finer work of the eye; the images of the poles are

surrounded by a false glow, because it is difficult to give the lens the proper curvature, and there is this power of dispersion which breaks the compound white light up into a number of its different elementary colours. It is this power of deviation which the lens possesses which enables it to bend the rays differently according to their different distances from its centre, and causes them to form an image at what is termed the focus of the lens. The rays of light passing through the outer part of the lens undergo



FIG. 15.—Telescope. A, object-glass, giving an image at B; C, lens for magnifying image B.

more deviation in order that they may be brought to a focus at the same point as the other rays. Now prisms which are made of different material, although they be of the same size and of the same angle, produce different deviations and different dispersions of the light which falls upon them. This fact has been taken advantage of in the construction of lenses. Let us take an illustration of the way in which this has been done. Imagine glass which gives a high dis-

persion and but slight deviation, set to work against glass giving great deviation with but little dispersion. It is obvious that it is quite possible by a combination of that character to keep the deviation and get rid of the dispersion, or to keep the dispersion and get rid of the deviation, as may be desired. By doing this an artificial eye of great excellence may be made. Suppose two different kinds of glass so combined as to form a prism, which should give a perfectly white image. Then the

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dispersion will have been got rid of, and the deviation will have been retained, and this is exactly what takes place in the modern compound, or, as it is called, achromatic lens. By building up a lens in this way we can get a much better image of the carbon poles of the lamp than before. This compound, achromatic lens, when used in a combination, is called the object-glass, because it is pointed to the object. But when it is a question of the combination of lenses, there is something else to be considered besides the mere formation of images. It is not enough to consider merely this, because when we spoke of the action of a convex lens in aiding us to read the vernier, we found that if an image was to be obtained the rays entering the eye must be practically parallel. In that case the rays always come to a focus at the same point. If the rays are not parallel, but divergent rays, then their focus will vary with the varying distance of the source of light.

In combining lenses together, then, it is important to bear in mind the fact that the rays of light which, after passing through the lenses ultimately reach the eye, must be parallel ones. Let us consider that arrangement which obtains in the telescope. In the simple form of this instrument, A (Fig. 13), representing the object-glass, receives the rays of light and forms an image of the distant arrow, from which they are supposed to flow, in exactly the same way that the lens we used just now formed an image of the carbon poles on the screen.

This image, then, having been observed, the eye views the distant object as if the object itself were placed at B. Remember now the way in which the eye was enabled to read the vernier placed close to it, and the action of the convex eyepiece of the telescope will be very obvious. In just the same way as the divergent rays coming from the vernier were grasped by the convex lens, and rendered parallel, so in this case the convex eyepiece of the telescope grasps the divergent rays from the image, reduces them

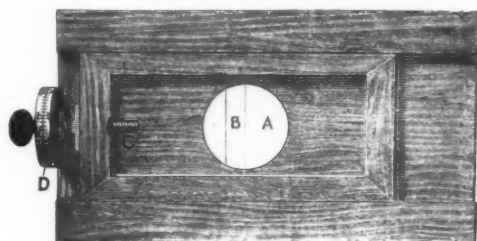


FIG. 16.—Model of Micrometer.

to the necessary condition of parallelism, and thus enables the image of the object to be clearly formed upon the retina of the observer's eye.

We have, then, got so far that by means of an object-glass we produce an aerial image, and by means of a convex lens we can view this image under conditions which enable another image of it to be formed on the retina. It is at once obvious that we can do something more than this, for if we place a concrete thing such as a cross wire at the same distance in front of the convex lens as the aerial image, or, in other words, at the focal distance of the object-glass, we shall see both the aerial image and the concrete thing, be it a cross wire or what not, both together. Now imagine that we can obtain an aerial image in this way of a star, and that side by side with this image of the star we observe the cross wire. It is quite clear that if we have any means of getting the cross wire to bisect the image of the star we shall have a much more accurate method of pointing at the celestial body, and therefore of measuring the angle between two celestial bodies, than was possible on the old system of sights without telescopes.

Suppose this telescope of ours to supplant the pointer of the old instrument of Tycho Brahe, consider the extreme accuracy of its observation as compared with that of the pointer in Tycho's quadrant, and it will be seen how vastly the application of these optical principles has added to the instrumental powers of the astronomer.

3. *How Optics enables us to Replace the Vernier by a Micrometer.*—But we have not yet done with optics. Its principles have been applied in yet another manner, but still, like these two applications which we have considered, tending to increase the

power of accurately measuring minute angular distances of space.

Fig. 14 shows a simple model which has been designed to illustrate the principle of the instrument called the micrometer. This instrument places in the hands of the astronomer the power of measuring with extreme accuracy the most minute distances. It consists of two vertical wires, one, A, fixed, the other, B, movable by the rotation of a very perfectly cut screw, seen at C. The head of the screw, D, is divided into 100 parts, and read by means of a vernier to 1/1000ths.

This system of threads moving over certain small distances which can be accurately measured by means of a micrometer screw, can replace the cross wires to which we have just referred, and there are two very notable applications of this principle to which reference must now be made. When the object-glass is used for astronomical purposes, it is naturally arranged to bring the rays which fall upon it from a celestial body, and which are practically parallel, to a focus which represents the actual focus of the lens for such rays, and which is called the principal focus. But it is not necessary that the rays which fall upon such a lens should be parallel. The lens acts under other conditions with this proviso, that the more the rays diverge from the body in front of it, or, in other words, the nearer the object is to it, the greater will be the distance behind the lens of the point at which the aerial image is formed.

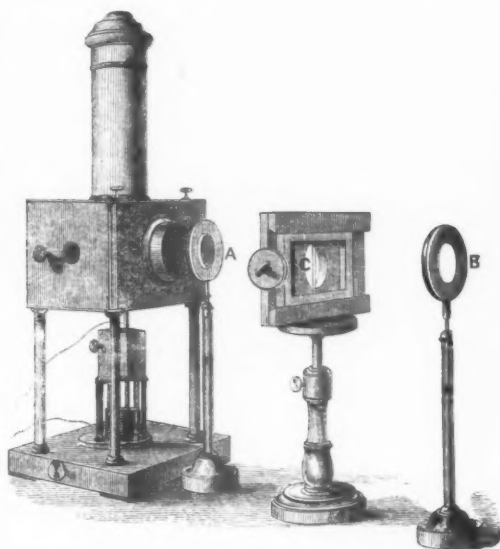


FIG. 17.—Micrometer arranged for demonstration with the electric light.

Here in a few words we have a statement of the arrangement used in the microscope, and a moment's thought will show that such an arrangement may be applied to the vernier instead of the small lens, to which reference has already been made. Nay, we can go further than this, it may be applied to the circle itself, and help us to measure small fractional divisions of its parts with yet greater accuracy than is possible by the aid of the vernier. The way in which this is managed is as follows:—The microscope is turned towards the circle, so that its divisions may be plainly seen in the field of view, and the position of the wire, on, or between any division may represent a certain position which is to be measured by means of the circle. The micrometer head may now be used to tell us the exact distance in 1/1000ths of a revolution between the position occupied by the wire in the first instance, and the position of the wire when it exactly lies on the next division. By determining, according to the graduation of the circle, the number of thousandths of parts as indicated by the micrometer which lie between each division, it is obvious that the exact angular distance between such a position and the next division of the circle can be accurately determined. Such an operation as this is called a "run," and practically such a

system as this is adopted in reading all large circles. But when it is a question of measuring smaller arcs, the micrometer may be used with the telescope itself, its wires appearing with the image of the object in the field of view.

A description of an experiment will perhaps convey a better idea of what can be done in this way. Fig. 15 represents the arrangement. The condensing lens of the lantern having been removed, the light is allowed to impinge upon a lens, A, placed at a slight distance from the lantern. Its action on the light causes a reversed image of the poles to be produced in the air. The light coming from this image is then made to pass through another lens, B; the reversal is corrected, and a magnified image of the poles of the electric arc is thrown upon the screen. The first lens which forms the image may be regarded as the object-glass of a telescope, whilst the other lens which throws the magnified image upon the screen is the counterpart of the telescope's eyepiece. Now if at C, where the image is formed in air, the micrometer wires are placed, they, with the image of the poles, will appear magnified on the screen.

In this manner bodies appear with the wires in the field of vision of the telescope, and their diameters and the dimensions of different parts of them may be most accurately determined. Up to the present time we have been concerned simply with accurately determining the positions occupied by the various bodies which people space. But with this micrometer in the field of view of the telescope something more than this may be done. We may now determine some measurements upon the bodies whose positions alone we have been considering up to now. For instance, the image of a planet may be grasped by the wires, one wire bounding one limb of the planet, the other wire lying along the other limb. Then, knowing how many complete turns, and 1/100th, and 1/1000th parts of a turn have been given to the head of a screw in order that the wires may be separated through such a distance, and knowing also the value of these divisions in seconds of arc, the diameter of the planet may be measured. In like manner, the heights of lunar mountains may be ascertained by measuring the lengths of the shadows thrown by them. Or it may be a question of the distance between two stars close together. The method is still the same. One star is made to lie along the movable wire, the other is seen on the fixed one, and the distance through which the wires are separated ascertained. Having attained to this, let us bring our inquiry into angular measurement to a close.

In passing, as we shall in the sequel, from the measurement of space to the measurement of time, it will be found that the difficulties have been grappled with very much in the same way. In this measurement of space we began with simple instruments, and only by a slow growth has the modern instrument been arrived at; yet notwithstanding the immense changes that have taken place, the pointer and circle of the old instrument are still represented in the new, whilst the vernier and micrometer, still preeminent, enable a degree of fineness to be attained quite unparalleled in the old days. But in passing from these older instruments, in which the circle was so prominent a feature, and the pointer so small, to the more modern instruments, it will be seen that, although both are still preserved, a great change has taken place. The pointer, represented by the telescope, is the prominent part of the instrument, whilst the circle is hidden away almost out of sight.

J. NORMAN LOCKYER

(To be continued.)

TABLE OF DIFFERENT VELOCITIES EXPRESSED IN METRES PER SECOND

THE following table has been drawn up by Mr. James Jackson, Librarian to the Paris Geographical Society:—

	Metres per second.
A man walking 4 kilometres an hour	1'11
" " " 5	1'40
The comet of Halley in aphelion	3'25
A ship going 9 knots an hour (9×1852 metres)	4'63
Ordinary wind	from 5 to 6
A ship going 12 knots an hour (12×1852 metres)	6'17
A wave 30 metres in magnitude with a depth of 300 metres	6'81
A ship going 17 knots an hour (17×1852 metres)	8'75
A fresh breeze	10
A torpedo boat going 21 knots an hour (21×1852 metres)	10'80

	Metres per second.
A race-horse trotting an English mile in 2 min. 14 sec.	12
" " galloping 900 metres a minute	15
An express train running 60 kilometres an hour	16'67
Flight of a falcon, of a carrier pigeon	18
A wave in a tempest at sea	21'85
An express train running 60 English miles an hour (60×1609 metres)	26'81
A tempest	from 25 to 30
The transmission of sensation by human nerves	33
A hurricane	40
Flight of one of the swiftest birds	88'90
Velocity of a point on the equator of Mercury	146'87
Propagation of the tide caused by the earthquake of Arica on August 13, 1868 (Arica to Honolulu), according to Hochstetter	227'38
Velocity of a point on the equator of Mars	244
" sound in the air ($+10^{\circ}$ C.)	337'20
" a point on the equator of Venus	454'58
" " " the Earth	463
A cannon ball	500
Propagation of the movement of tides (North Pacific Ocean); maximum according to Whewell	922
The moon's revolution round the Earth	1012
Velocity of a point on the equator of Mercury	1034
Revolution of the second satellite of Mars	1157
Concession of the earthquake of Viège (July 25, 1855); from Turin to Geneva in 126 seconds	1368
Velocity of sound in water ($+8^{\circ}$ C.)	1435
Revolution of the first satellite of Mars	1833
Velocity of a point on the equator of the Sun	2028
Revolution of the fourth satellite of Uranus	3300
" " eighth " Saturn	3738
" " third " Uranus	3814
Velocity of a point on the equator of Uranus	3904
Revolution of the satellite of Neptune	4505
" " second satellite of Uranus	4906
" of Neptune round the Sun	5390
" of the first satellite of Uranus	5763
" " seventh " Saturn	5794
" " sixth " " "	6398
" of Uranus round the Sun	6730
Proper movement of Vega	7000
Displacement of the sun towards the constellation of Hercules	7642
Revolution of the fourth satellite of Jupiter	8359
" of Saturn round the Sun	9584
" of the fifth satellite of Saturn	9741
Velocity of a point on the equator of Saturn	10,541
Revolution of the third satellite of Jupiter	10,869
" " fourth " Saturn	11,516
Velocity of a point on the equator of Jupiter	12,491
Revolution of Jupiter round the Sun	12,924
" of the third satellite of Saturn	13,038
" " second " Jupiter	13,999
" " " Saturn	14,568
" " first " " "	16,425
" " " Jupiter	17,667
" of Mars round the Sun	23,863
" of the Earth " " "	29,516
" of Venus " " "	34,630
Proper movement of Capella	40,000
Revolution of Mercury round the Sun	47,327
Proper movement of Sirius	51,000
Ordinary movements of the solar atmosphere	from 30,000 to 65,000
Proper movement of the 61st of Cygnus	71,600
" " " Arcturus	85,000
The comet of Halley in perihelion	393,260
Tempests of the solar atmosphere	402,000
Electricity; a telegraphic submarine wire	4,000,000
" " " aerial	36,000,000
Velocity of light	300,400,000

THE BRITISH ASSOCIATION REPORTS

Report of the Committee on Electric Standards, read by Mr. R. T. Glazebrook.—This comprised an account of the means

adopted at the Cavendish Laboratory for comparing resistance coils sent to be tested with the B.A. units.

Report of the Committee on the Harmonic Analysis of the Tides was read by Prof. Adams, who said that the Indian Government were entitled to great gratitude for carrying on tidal observations for many years on a thoroughly scientific system, and he thought they might be held up as an example to our own Government, which was very niggardly in these matters. He suggested that tidal observations should be made on the coast of the English Channel, as there were certain peculiarities in the tide which ought to be investigated.

Report of the Committee appointed to Cooperate with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis was drawn up by Mr. Murray for Prof. Crum Brown. Stations had been established at various points at which observations were made by the observer, Mr. Wragge, half-hourly as he ascended or descended the mountain. Simultaneous observations were made at Fort William. The diurnal curves for pressure, temperature, and humidity have been drawn, and show the insular character of the climate markedly. At the top the degree of saturation and its persistency is important. In 1881 this was a specially marked feature under the approach of numerous cyclones from the Atlantic; in 1882 anti-cyclones prevailed, and there were frequent changes from saturation to extreme dryness—a dryness comparable with that of the Sahara—occurring in very short intervals of time. This extreme dryness was accompanied by a very high temperature. The results are to be analysed shortly by Mr. Buchan for the Scottish Meteorological Society.

Sixteenth Report of the Committee appointed for the Purpose of Investigating the Rate of Increase of Underground Temperature Downwards in various Localities of Dry Land and under Water was read by Mr. J. Glaisher. The observations were made at an artesian well at Southampton, Dolcoath Mine, North Seaton Colliery, Ashton Moss Colliery, and Ashton-under-Lyne. The report concluded by stating that if we assumed 1° in 57.8 feet as the rate for the St. Gothard Tunnel, and also for the Mont Cenis Tunnel, the effect upon the general mean for all places will be to make it 1° F. in 60 feet, instead of 1° F. in 64 feet.

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE

On the Forms of the Sun's Influence on the Magnetism of the Earth, by Prof. Balfour Stewart.—The author endeavoured to show that there are two forms of solar influence:—

A. That which produces the diurnal variation, the range of which is greatest a little after the time of maximum sunspot frequency.

B. That which produces a magnetic change on the earth as a whole; and this, too, acts in such a manner that the intensity of terrestrial magnetism is apparently greatest after a maximum of sunspots.

It is with this second form of influence that the author deals, and he endeavours to show that it leads—

1. To simultaneous increments or decrements of the horizontal force at various states as observed by Broun.

2. To two maxima of horizontal force at the solstices and two minima at the equinoxes, as observed also by Broun.

3. It appears that the strength of solar action, when the sun is favourably disposed with regard to the northern hemisphere (June) is greater than when it is favourably disposed with regard to the southern hemisphere (December), a circumstance which leads to an annual variation.

4. It also appears that it is what has been termed the induction system of the earth that is thus affected by the sun.

On the Heating Power of the Sun's Rays at London and at Kew, by Professors Roscoe and Balfour Stewart.—The observations discussed were made by Campbell's method, in which a spherical glass lens had its focus along the surface of a hemisphere of wood, so that, whenever the sun shone, a portion of the wood was burned. The wooden hemisphere was renewed twice every year, namely, at the solstices. The following results were obtained from the observations, by a process in which the burned volume was filled up and the increase in weight accurately measured:—

1. The heat of the sun for the half year between the June and the December solstice is greater than that for the half year between the December and the June solstice, but this difference

is more marked at London (Board of Works) than at the Kew Observatory.

2. The annual value of the sun's heat is greater at Kew than at London in the proportion of 100 to 58.

3. The annual value of the sun's heat is peculiarly great about the period of maximum sunspots, but there are indications of a double heat-curve for one of sunspots, so that there is a subsidiary maximum of heat about the period of minimum sunspots.

On Supposed Sunspot Inequalities of Short Period, by Prof. Balfour Stewart and William Lant Carpenter, M.A.—Putting aside in the meantime the question of true or nearly apparent periodicity, the authors exhibited certain results obtained by this application of a method for detecting unknown inequalities in a mass of observations. This has been applied to thirty-six years' observations of sunspots, which have been divided into three series of twelve years each. Two apparent sunspot inequalities of about twenty-six days come out very prominently by this treatment, appearing for each of the twelve years in the same phase, and to very nearly the same extent. If the average value of sunspots for each year be reckoned = 1000, this is reduced to less than 900 at the minimum of the inequalities, and increased to more than 1100 at their maximum, so that the average range is more than one-fifth of the average value, a result of very considerable prominence.

Prof. Chandler Roberts read a paper *On the Rapid Diffusion of Molten Metals*. The two metals chosen were lead and gold inclosed in a letter U-shaped tube, the lead occupying the lower portion of the tube, and the gold being put in at the top of one limb. After about forty minutes Prof. Roberts found that the two metals had been thoroughly mixed.—Sir W. Thomson called attention to the extreme importance of this with reference to metallic alloys, and remarked that it resembled the diffusion of gases or of heat in a gas rather than of a solid in a liquid. Salt would take years to diffuse in a similar manner through water.

Mr. W. G. Black described a simple form of marine anemometer, in which the pressure of the wind on a sail of known area was registered by a spring balance. The sail could be easily placed in any required position on the ship, and set by means of a vane to the proper angle with the wind.—The arrangement was criticised by Prof. Hele Shaw, who described a form of his own which he had used for measuring water currents. This consisted of two light vanes, movable about the same vertical axis, and pressed outwards by a spring. The wind tended to make the vanes close up together, and their motion gave an indication of its velocity.

Papers on *The Standard of White Light*, and on *The Relation between Temperature and Radiation*, by Capt. Abney, and Sir C. W. Siemens respectively. Capt. Abney suggests as a high temperature standard an incandescent lamp. The light of this is compared by means of the spectrophotometer with that from Prof. Vernon Harcourt's standard lamp, afterwards described. The green light in the neighbourhood of E should be about one and a half times that of the gas standard, while the red light should be the same in the two. In a recent paper Capt. Abney criticised some of Sir W. Siemens's experiments of a similar nature. Sir William had used platinum wire in air instead of carbon in a vacuum, and the paper read was a reply.—In the discussion Dr. Schuster pointed out that a similar method, free from many of the difficulties under consideration, had been suggested by the late Prof. Clerk Maxwell, and apparatus for making the experiments was constructed by him shortly before his death.

Prof. Vernon Harcourt gave a description of a lamp for producing a standard light. It was arranged for burning air and the vapour of petroleum, mixed in the proportion of three cubic inches of vapour at a temperature of 60° F. to one cubic foot of air. The mixed gas is allowed to escape from a hole of a quarter of an inch in diameter, and burn in a flame two and a half inches high. Prof. Harcourt showed that the height of the flame was an index of the proportion in which the gases mixed, and was constant when the mixture remained constant.

Mr. E. P. Culverwel read a paper *On the Probable Explanation of the Effect of Oil in calming Waves in a Storm*. He said when the surface of the sea had become smooth after a storm it was very common for long rollers to break on a sand-bar. If there were no wind and the sea was glassy, these would not break until quite close to the shore, even though the ordinary theory pointed to their breaking earlier, unless there was a force directed opposite to that of their motion. When exerted on the waves, such a force might be supplied by the wind; but if it rose in any direction the waves broke much sooner. This result

was therefore due to some secondary effect produced by the wind pressure, and not directly by the pressure itself, and it was to the ripples produced on the surface, which disturbed the wave motion, that the speedy breaking was to be attributed. It was, however, a direct result of the theory that the ripples depended on surface tension for their propagation, and could not exist in large amount on the oiled surface. It was also evident that the hold of the wind on the wave was greatly decreased by the absence of ripples, and thus the oil acted both to prevent the wind having much effect on the surface, and also to modify the motion of the water in the wave.

Prof. Stokes read a paper by Dr. Huggins *On Coronal Photography without an Eclipse*. In a paper read before the Royal Society some time back, Dr. Huggins had shown that it was possible by isolating, by means of properly chosen absorbing media, the light of the sun in the violet part of the spectrum to obtain photographs of the sun surrounded by an appearance distinctly coronal in its nature. These researches have been continued, using a reflecting telescope by the late Mr. Lassell, and a film of silver chloride as the sensitive plate on which the photograph is taken. These plates are sensitive to the violet light only, and therefore it was unnecessary to use absorbing media which had proved a source of difficulty to sift the light. Fifty photographs in all were taken and examined afterwards by Mr. Wesley, who made drawings of them for the paper.—Dr. Ball, who was in the chair, examined some of the plates, and spoke of the interest and importance of this communication.

Prof. Schuster read a paper *On the Internal Constitution of the Sun*. He had calculated the volume of the sun from its mass, assuming that it consisted of a gas subject to gaseous laws and in the state of convectional equilibrium discussed by Sir William Thomson. The paper showed that, if the rates of the specific heats of the gas were less than 1.2, the volume of the sun would be immensely larger than at present, while, if greater than 2.0, the sun's volume would be far smaller than it is. The result that the rates of the specific heats must lie between 1.2 and 2.0 is so far in agreement with received theories of the constitution of the sun.

Notes on some recent Astronomical Experiments at High Elevations on the Andes, by Ralph Copeland.—These experiments were made during the first half of the present year at the cost of the Earl of Crawford. At La Paz, in Bolivia, 12,000 feet, with the full moon in the sky, ten stars were seen in the Pleiades with the naked eye, and also two stars in the head of the Bull that are not in Argelander's *Uranometria Nova*. The rainy season lasted roughly until the end of March, after which there was a large proportion of fine sky. At Puno, on Lake Titicaca, 12,600 feet, with a 6-inch telescope mounted on a lathe headstock, a number of small planetary nebulae, and some stars with very remarkable spectra, were found by sweeping the southern part of the Milky Way with a prism on Prof. Pickering's plan. The most remarkable stars had spectra reduced almost to two lines, one near D, and the other beyond F, with a wave-length of 467 mm., and apparently identical with a line in some only of the northern nebulae as observed by Mr. Lohse and Mr. Copeland. A few close double-stars were also found, amongst them β Muscae.

At Vincocaya, 14,360 feet, the solar spectrum was examined with a somewhat damaged instrument. The chief fact noted was the relative brightness of the violet end of the spectrum. With a small spectroscopic several lines were seen beyond H and H₂. The prominences were visible with almost equal facility in C, D₃, F, and H₂. Attempts to see the corona proved futile, nor were the prominences seen otherwise than in the spectroscopic, the only difference being that the slit could be opened far wider than down at the sea-level. A most careful examination of the zodiacal light failed to show even the slightest suspicion of a line in its spectrum, which was continuous although short. Both at Puno and Vincocaya the air was very dry the relative humidity there and at Arequipa, 7700 feet, being as low as 20 per cent. At Vincocaya the black bulb at one time stood above the local boiling point, while the wet bulb was coated with ice. The author was of opinion that an observatory might be maintained without discomfort up to 12,000 feet, or even a little higher—the night temperature falling only slightly below the freezing point. At greater elevations the thermometer falls 1° for every 150 feet of height, the barometer sinking about 0.1 inch for the same change. At 15,000 feet it will thus be seen that arduous winter conditions are reached without any very material gain in the transparency of the atmosphere. From information received it seems possible to maintain a station for a

short time in the early summer as high as 18,500 feet; later on the rains set in and render travelling very difficult. Railway and steamboat communication enable instruments of any size and weight to be carried as high as 14,660 feet, and as far as the Titicaca shore of Bolivia.

OUR ASTRONOMICAL COLUMN

PONS' COMET.—The following ephemeris is deduced from MM. Schulhof and Bossert's provisionally corrected elements:—

1883.	At Greenwich Midnight			Decl.	Log. distance from Earth.	Sun.
	h.	m.	s.			
Oct. 16	16	39	53	+55 37.7	0.2653	0.2723
18	—	42	19	55 13.7	—	—
20	—	44	57	54 50.0	0.2520	0.2600
22	—	47	47	54 26.5	—	—
24	—	50	48	54 3.3	0.2378	0.2472
26	—	54	1	53 40.4	—	—
28	16	57	27	53 17.7	0.2226	0.2340
30	17	1	5	52 55.3	—	—
Nov. 1	—	4	56	52 33.1	0.2065	0.2204
3	—	9	0	52 11.2	—	—
5	—	13	18	51 49.4	0.1894	0.2062
7	—	17	49	51 27.6	—	—
9	—	22	37	51 5.9	0.1710	0.1916
11	—	27	40	50 44.1	—	—
13	—	32	59	50 22.0	0.1513	0.1764
15	—	38	35	49 59.6	—	—
17	—	44	29	49 36.8	0.1303	0.1607
19	—	50	42	49 13.4	—	—
21	17	57	16	+48 49.1	0.1079	0.1445

The intensity of light will be three times greater on November 21 than on October 16, and will increase until near the middle of January. According to the experience of 1812, we might expect it to draw within naked-eye vision at the beginning of December, but it is not likely to attain a brightness at all comparable with the conspicuous comets of the last few years. It may rather be anticipated that when best seen, its light will be nearly that of stars of the third magnitude. We are of course assuming the comet not to have undergone material change since its last appearance. On the morning of August 18, 1812, the Paris astronomers have the note:—"La comète commence à être visible à l'œil nu; son noyau assez brillant, est enveloppé d'une chevelure et sa queue est d'environ 1½ à 2°." Employing MM. Schulhof and Bossert's final orbit, we find that at the hour of observation, about 2h. 30m. a.m. G.M.T., the comet was in R.A. 114° 24', Decl. +44° 27', distant from the earth 1.4713, and from the sun 0.9449, so that the intensity of light, expressed in the usual way, would be 0.52, which corresponds to that on December 1 in the present year. On the morning of September 14 it was remarked:—"La queue de la comète est divisée en deux branches parallèles; sa longueur paraît d'environ 3 degrés." At 4h. 30m. a.m. G.M.T. the comet was distant from the earth 1.2324, and from the sun 0.7778, whence, the earth's radius-vector being 1.0051, the angle at the comet was 54° 29', and with Newcomb's solar parallax, the real length of the tail, if extending as most usual in the direction opposite to the sun, would be 7,600,000 miles, or a little over.

In announcing the discovery of this comet by Pons at Marseilles on July 20, 1812, Zach remarked (*Monatliche Correspondenz*, xxvi. 270) that it was the sixteenth (? fourteenth) comet which he had independently discovered within ten years. So indefatigable a worker in this direction well deserves that his name should be permanently associated with at least one of his discoveries, and none presents itself as affording a more fitting case than the comet of 1812.

SWIFT'S COMETARY OBJECT.—It would appear from unsuccessful search at European and American observatories that Mr. Swift must have been mistaken in supposing he had observed a comet in the places published in *Astron. Nach.*, No. 2541.

THE CORDOBA OBSERVATORY.—Dr. B. A. Gould, director of the Observatory at Cordoba, passed through London last week en route for South America, after attending the meeting of the "Astronomisches Gesellschaft" at Vienna, and that of the International Standard Commission at Paris. We learn from Dr. Gould that the printing of the second volume of Cordoba Zones is nearly completed in London. The attention of this

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indefatigable astronomer will soon be directed to the publication of another great work undertaken by him at the Argentine National Observatory, viz. the Cordoba General Catalogue of Stars.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The commencement of the Michaelmas Term has been marked this year by an event of happy augury for the advancement of science in Oxford. Prof. Burdon-Sanderson opened the physiological department in the University Museum with an inaugural address, in which the aims and scope of physiology were defined with scientific accuracy and singular literary charm. The Professor showed the great importance of physiological methods for the advance of pathology, and ended by promising his future students something more interesting to study than "dry bones."

Prof. Sanderson gives a regular course of lectures on the "Mechanical Functions of the Animal Body," and the physiological laboratory is open for practical instruction under the Professor and two assistants.

Mr. Yule also has a class at Magdalen for Practical Physiology. In the Department of Animal Morphology Prof. Moseley lectures on Comparative Anatomy, each lecture being followed by practical instruction. Mr. W. H. Jackson lectures on Mimicry and Parasitism; Mr. E. B. Poulton on the Fundamental Tissues, and Mr. W. L. Morgan on the Limbs of Vertebrata.

Mr. E. Chapman has a class at Magdalen for the study of Vegetable Histology.

In the Physical Department Prof. Clifton lectures on the Properties and Means of Measuring Electric Currents; practical instruction in Physics is given by Prof. Clifton and Messrs. Heaton and J. Walker. Mr. Heaton gives a course of lectures on Mechanics.

At Christ Church Mr. Baynes has a class for practical instruction in magnetic and electrical measurements. At Balliol Mr. Dixon gives an elementary course of lectures on Electricity and Magnetism.

In the Chemical Department Prof. Odling lectures on the "Naphthalene Family." Lectures on Inorganic and Organic Chemistry are given by Mr. Fisher and by Dr. Watts. Practical instruction is given by Mr. Fisher, Dr. Watts, and Mr. Baker. At Christ Church Mr. Vernon Harcourt forms a class for "Examples in Quantitative Analysis."

Prof. Prestwich lectures on the "Elements of Geology." Prof. Story-Maskelyne lectures on "Crystallography."

The Natural Science Scholarship at Exeter College has been awarded after examination to Mr. E. H. Cartwright, of Charterhouse School.

Natural Science Scholarships are offered for competition this term by Christ Church and Balliol Colleges.

CAMBRIDGE.—The outgoing Senior Proctor, Mr. Torry, in his address on laying down office, referred to the present system of granting M.A. degrees without examination, and suggested that all who had not already taken honours should be required to pass for M.A. in some specified portion of one of the honours examinations.

Prof. Darwin will lecture this term on gravitation, and consider some of the mathematical problems which arise in the theory of the figure of the earth, measurements of base lines and arcs of meridian, pendulum experiments, the Cavendish experiment, and cognate subjects.

The Demonstrator of Mechanism will take a class in rigid dynamics, with a view to its applications in engineering; and also a preparatory class in the differential calculus.

At the annual election to Fellowships at Trinity College, Mr. R. A. Herman, Senior Wrangler and First Smith's prizeman in 1882, was elected a Fellow. Mr. W. R. Sorley was elected to the Fellowship given for mental and moral science.

The election to the Knightbridge Professorship of Moral Philosophy will take place on November 1. The electors are Professors Caird, Fowler, Hort, and Seeley, Drs. Campion and Todhunter, Mr. Leslie Stephen, Mr. Venn, and the Vice-Chancellor.

Prof. Cayley lectures this term on higher algebra and the theory of numbers.

The Demonstrator of Comparative Anatomy is conducting an advanced class on the Protozoa and Coelenterata.

Messrs. A. J. C. Allen (Peterhouse), and C. Graham (Caius),

have been appointed moderators for the year beginning in May next.

Prof. Garnett, Dr. Vines, and Mr. Pattison Muir are appointed examiners for the first M.B. examinations; Prof. Milnes Marshall, Dr. Gaskell, and Dr. Shuter for the second M.B. examinations of the current year.

Mr. Stearn is lecturing on electrostatics at King's College, with special reference to theories of electric displacement, specific inductive capacity, and the strain in a dielectric.

SCIENTIFIC SERIALS

Bulletins de la Société d'Anthropologie de Paris, tome 6, série 3, 1883.—In a discussion on polyandry in Cashmere and Thibet, M. Olivier Beauregard maintained that this practice prevailed among the early Aryan races of Hindostan 2000 years before the Christian era, as shown in the first book of the Mahābhārata, from which he made several interesting extracts bearing on this point. His views were strongly contested by M. Ujfalvy.—"Remarks on the character of the crania of native South Australians," by M. Cauvin, who made a series of anthropometric determinations while engaged at Sydney in prosecuting his researches into the morphological characteristics of the Oceanic races.—M. de Ujfalvy, in a communication on the "Traces of the Ancient Cults of Central Asia," described the various superstitions which point to an earlier Vedic faith, and to a fire-worship among races who now adhere either to Hinduism, or Islamism, while in the heart of Central Asia the majority of the tribes are still followers of the "Old Man of the Mountains," or the belief of the "Assassins." He believes that the introduction of *Mazdeism* and *Brahmanism* was probably contemporaneous, and that these ancient cults were preceded by a form of Shamanism in which the products of nature were worshipped.—On human sacrifices among the Khonds of India, by M. E. Reclus. The author regards these so-called *mériahs* as a survival of an early practice of the ancient agricultural tribes of Asia, who believed that blood was necessary to the fertility and nutritive qualities of the fruits of the earth.—On the population of Western Laos, by M. Carl Bock. This memoir is remarkable for its minute ethnographic details and for the number of its anthropometric determinations, and treats of the political and social relations of the six Laotian States which pay tribute to Siam.—A discussion on the supposed practice of the "Covade among the Basques," in which M. Vinson, who has been twelve years resident among the people, denies the existence among them of any such custom, and gives his reasons for doubting the assumed affinity of this people with the Iberians. M. E. Reclus thinks the existence of such a practice might perhaps be connected with the transition from the metronymic to the patronymic principle of family government; and that from an ethnological point of view the question of its reality, to which many of the best known classical authors have given their testimony, is worthy of attention.—On the prehistoric lasso, by M. Chauvet.—Report, by M. Nicaise, on the discovery of human bones, associated with Quaternary animal remains and worked flints, in the alluvial deposits of the Marne Valley near Chalons, with plan of locality, &c.—On the significance of the principal humeral of the biceps, by M. Leo Testut, with special reference to the contradictory opinions of Hyrtl and Calori.—Report on the brain of Louis Asseline, by MM. Duval Chudzinski and Hervé, with diagrams of various aspects of the hemisphere. M. Duval's assertion that Asseline's brain presented various simian characters drew forth M. Foley's strongly expressed reprobation, while M. Dally considers that the more general admission of a close anatomical affinity between man and the lower animals would be conducive towards morality, by lessening the cruelties wantonly inflicted on the latter.—Report of commission for the preservation of megalithic monuments, on the remains of dolmens of Port Blanc (Quiberon).—On a prehistoric case of dental abnormality, by Dr. Bernard.—Report on the adjudication of the Prix-Godard for 1883, by M. L. Rousselet, who passed in review the several labours of M. Chantre, to whom the prize has been awarded in consideration of the merits of his palaeolithic atlas of France, and for his work on the Iron Age, while M. Prengreuer receives a silver medal, with honourable mention, for his anthropometric measurements of the Kabyles.—On dental erosions in the dog, by M. Capitan.—On the steatopygia of the Boshman women, by Dr. Blanchard.

Journal de Physique théorique et appliquée, September, 1883.—On the critical point of liquefiable gases, by J. Jamin.—On the compressibility and the liquefaction of gases, by J. Jamin.—

Note on the coloured fringes in films of uniaxial crystals, and on their projection in monochromatic light, by A. Bertin.—Optical apparatus for verifying plane surfaces, whether parallel, perpendicular, or oblique, by Léon Laurent (with diagrams).—Theorem relative to ramified linear currents, by L. Thévenin.—Horizontal capillary electrometer, by Ch. Clavierie.—Sonorous vibrations of solids in presence of liquids, by F. Auerbach.—A measurement of wave-length in the ultra-red of the solar spectrum, by E. Pringsheim.—Researches on the proportion of carbonic acid in the air, by J. Reiset.—Researches on the proportion of carbonic acid contained in the air, by A. Müntz and E. Aubin.—On the normal amount of carbonic acid in the air, by M. Dumas.—Experimental researches on the thermal conductivity of minerals and rocks, by J. Thoulet.—Analytical researches on the method of J. Thoulet relative to thermal conductivity, by A. Lagarde.—On the diffusion of an impalpable powder in solid bodies, and On pig iron transformed to steel by cementation, by Sydney Marsden.—On the electrolysis of hydrogen peroxide, by M. Berthelot.—Detection of hæmoglobin in the blood by optical methods, by E. Franly.—Measurement of the rotation of the plane of polarisation due to the magnetic influence of the earth, by H. Becquerel.—A new apparatus for determining specific heats, by W. Louguine.—Reversal of line spectra of metals, by Living and Dewar.—Boiling points and vapour tensions of mercury, sulphur, and some complex carbon compounds determined by the hydrogen thermometer, by J. M. Crafts.

Atti of the Royal Academy dei Lincei, June 3.—Obituary notice of the late Rainardo Dozy, with a complete list of the illustrious *savant's* writings, by Sig. Amari.—Remarks on Giunti's researches on the influence exercised by some physical agencies on alcoholic fermentation, by Sig. Cossa.—On the rotatory power of the isomeric photosantonio acid $C_{15}H_{20}O_4$, by Sig. Nasini.—Two important results of Hall's electric phenomenon, by Sig. Blaserna.—On the spontaneous oxidation of mercury, by S. Damiano Macaluso.—On the equilibrium of elastic and rigid surfaces, by S. Giacinto Morera.—On a new method of anaesthesia, obtained by disassociating the motor and sensitive functions of the nervous system, by S. A. Moriggia.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, October 8.—M. Blanchard, president, in the chair.—On the force of explosive substances, by M. Berthelot. In reference to the work in two volumes just published by him on this subject ("Sur la Force des Matières explosives d'après la Thermo-chimie, Gauthier-Villars, 1883), the author explains that the theory there advanced is the result of thirteen years' experimental researches reported from time to time in the *Comptes Rendus* of the Academy. The first part is devoted to general notions, and in particular to the development of his theory on the propagation of explosive phenomena and on the explosive wave, the discovery of which throws quite a new light on the whole subject. In the second part are recorded the various experiments and researches made by the author on the electric fixity of nitrogen. In the third part the principles and numerical data thus determined are applied to define in particular the force of detonating gases, nitro-glycerine, nitromannite, dynamite, gun-cotton, picrates, and other powerful explosive substances. The history of the origin of gunpowder and other explosives is consigned to an appendix, and the work is enriched with full analytical tables and alphabetical indexes.—Report on the earthquake felt at Ischia on July 28, 1883, with remarks on the probable causes of seismic disturbances, by M. Daubrée. The author rejects Prof. Palmieri's view that the catastrophe was connected with the presence of old quarries and other cavities whose supports gave way and thus caused a sudden subsidence of the ground at Casamicciola. He holds, on the contrary, that it was due to the volcanic forces, by which the island has often been wasted, and notably in the years 1828, 1867, and 1881. On the general question of the nature and cause of these disturbances he holds with Dolomieu that they must be regarded as suppressed volcanic eruptions. Gaseous bodies formed in underground cavities, the vapour of water penetrating from the upper crust, subjected to great pressure, sufficiently superheated, and set in motion from time to time by a simple natural process, suffice to account for all the essential phenomena associated with earthquakes.—Reply to a note by M. Thollon on the interpretation of a phenomenon of the solar spectrum, by M. Faye. The author appeals to data supplied by Secchi and others in support of his views

and against the reality of the velocity of 100 to 150 leagues per second usually assigned by spectroscopists to the movements of the hydrogen in the solar protuberances.—On the measurement of the forces brought into play in the various acts of locomotion (one illustration), by M. Marey.—On the coexistence in a specimen of guano of effervescent carbonate of ammonium with water and sulphate of potash, by M. E. Chevreul.—On the symmetrical character of the so-called adventive roots in plants, by M. D. Clos.—After the reading of this paper allusion was made by the President to the loss sustained by the Academy in the person of Dr. Oswald Heer, Corresponding Member of the Botanical Section, who died at Lausanne on September 27.—On the financial aspect of the great works of irrigation in France and the north of Italy, by M. Ar. Dumont.—Observations on the Pons-Brooks comet and the planets 142, 185, 221, and 234 made at the Paris Observatory (equatorial of the West Tower), with note on the remarkable variation in brightness of the Pons-Brooks comet, by M. G. Bigourdan.—On a remarkable peculiarity presented by the tail of the great southern comet of 1882, by M. L. Cruls.—On the approximate evaluation of integers, by M. Stieltjes.—On the induction produced by the variation of intensity of the electric current in a spherical solenoid, by M. Quet.—On the products formed in the fermentation of the sugar-cane due to the properties of the soil, by MM. Dehérain and Maquenne.—On the wheats of India, by M. Balland. The specimens of Indian wheat flour examined by the author revealed the presence of about 3 per cent. of *Vicia peregrina*, *Cicer arietinum*, and other leguminous flours.—On poisoning by the bacilli of the jequirity (one illustration), by MM. Cornil and Berlioz.—On the influence of beet-pulp on the milk of the cow, by MM. Andouard and V. Dézaunay. From their experiments the authors conclude that the milk of cows fed on beet-pulp increases in quantity, but deteriorates in quality.—On the geological age of the serpentine rocks and ophiolitic formations of Corsica, by M. Dieulafoy.

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